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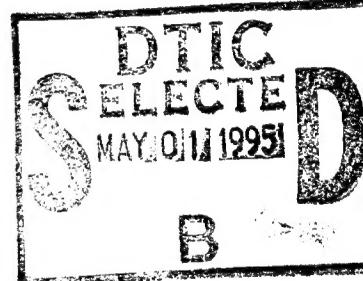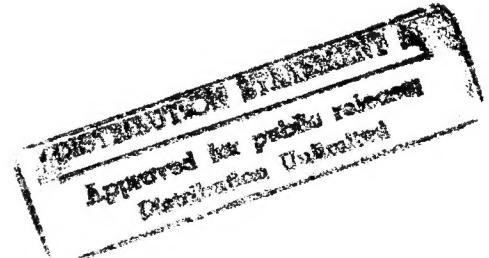DTIC
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The European Science Notes Information Bulletin (ESNIB) 90-06 is a compilation of reports on recent developments in European science of specific interest to the U.S. research and development community, and is issued in support of the mission of the Office of Naval Research European Office. Issue Number 90-06, in addition to European area news, notes, and abstracts, contains reports in the fields of Acoustics, Applied Mathematics, Communications, Computer Science, Information Technology, Mathematics, Physics, Psychology, and Solid-State Physics. The value of the ESNIB to Americans is to call attention to current activity in European science and technology and to identify the institutions and people responsible for these efforts. The ESNIB authors are primarily ONREUR staff members; other reports are prepared by or in cooperation with staff members of the USAF European Office of Aerospace Research and Development or the U.S. Army Research, Development and Standardization Group. Scientists from the U.S. who are traveling in Europe may also be invited to submit reports.

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ESN Information Bulletin

ACOUSTICS

APPLIED MATHEMATICS

BIOTECHNOLOGY

COMMUNICATIONS

COMPUTER SCIENCE

INFORMATION TECHNOLOGY

MATHEMATICS

PHYSICS

PSYCHOLOGY

Selected highlights from this international symposium are discussed. The highlights are: neural network simulations on transputers, prospects of commercial neural network applications, and brain research on the sensory and motor systems neural control.

SOLID-STATE PHYSICS

The Mauterndorf winter school is popular among academics since it exposes advanced graduate students and postdoctoral researchers to topics of current interest in an atmosphere that stimulates casual scientific interactions.

According to a recent report, the superconducting synchrotron x-ray source have been successful and HELIOS will be shipped to its first customer in the fourth quarter of 1990.

NEWS, NOTES, AND ABSTRACTS

ACOUSTICS

8th FASE Symposium on Environmental Acoustics

by David Feit, the Liaison Scientist for Acoustics and Mechanics in Europe and the Middle East for the Office of Naval Research European Office. Dr. Feit is on leave from the David Taylor Research Center, Bethesda, Maryland, where he is a research scientist in the Ship Acoustics Department.

Introduction

The Federation of Acoustical Societies of Europe (FASE) held its 8th periodic scientific meeting in Zaragosa, Spain, April 24-28, 1989. The theme of the meeting was environmental acoustics. This subject is of great interest to the Municipality of Zaragosa and the Mutua de Accidentes de Zaragosa. Anyone who has walked in the traffic congested streets of some large cities in Spain quickly becomes aware of the noise pollution problems facing the urban residents of Spain. One can well imagine the political interest in trying to solve such problems. Because of this, these two organizations had co-organized a meeting on the same subject 2 years ago and they, together with the General Direction of the Environment of the Ministry of Public Works and the Spanish Acoustical Society, joined to organize this FASE symposium.

A. Lara-Saenz, President of the Spanish Acoustical Society, presented the opening lecture. The subject of his talk was noise level limits for hearing protection.

In addition, there were 3 invited lectures and 83 contributed papers presented during this 5-day meeting. Attendees received the Proceedings at the beginning of the meeting. The official languages of the meeting were English, French, and German. The categories of papers are:

- Moving and stationary noise sources
- Physics of noise
- Noise emission
- Effects of noise
- Sociological effects of noise
- Analysis and evaluation of noise
- Vibrations.

In this report, I will briefly summarize the opening and invited lectures. Then I will discuss a selected number of contributed papers that I found interesting.

Opening and Invited Lectures

Lara-Saenz began his talk stating that the resolution of complex sounds into their component frequencies is the most important function of the auditory sense. To preserve this sense, governing bodies introduce laws and regulations to protect the public against intense noise. If left unchecked, these can lead to serious physiological and psychological effects in people. The purpose of the conference was to present findings related to understanding the correlation between the physical parameters of noise exposure with hearing damage. After discussing damage risk and criteria, Lara-Saenz gave an overview of some national and international standards for damage risk criteria that have been proposed concluding with the 1986 European Economic Community Directive 86/188. This directive, derived after several years of discussion, is designed to protect workers from hearing impairment caused by workplace noise exposure, and follows the total energy criteria that, in his view, calls for reasonable level limits.

Invited Lectures

R. Josse, Centre Scientifique et Technique du Batiment (CSTB), St. Martin d'Heres, France, gave the first invited lecture. He discussed the comparative use of scale models and numerical methods in road traffic noise studies. Traffic noise is one of the principal annoyances throughout many European countries. A French study in 1986 showed that about 60 percent of the respondents cited traffic noise as the major annoyance in the home. He then discussed using the dB(A) as a sound level measure to characterize traffic noise throughout Europe. After discussing the calculational modeling of traffic noise, he pointed out the associated difficulties. He used this to justify and introduce the scale model facility, one of two in the world, the other at Kobayashi University, Japan, that has been built up at the CSTB. This facility resides in a 1,300 m^3 semi-anechoic room with 1/100 to

1/20 scale models installed on a 10x10-m platform and a controlled environment. In his concluding remarks, he compares the merits of scale models versus numerical methods. Because of the difficulties in simulating climactic conditions in a laboratory, probably numerical modeling will be the predominant choice in the future. There is a need for a laboratory dedicated to the experimental modeling of road noise that can be used in a research mode rather than for operational studies.

Emphasizing the other end of the spectrum, E.J. Rathe, Swiss Federal Institute of Technology, Russikon, Switzerland, spoke about calculational models for outdoor noise propagation. According to him, a measurement does not by itself solve the problem, since it is never more than a particular sample taken from a large variety of possible conditions. As such, it provides a useful experience for each sample condition, and is a collection and arrangement of a large range of experience that he calls an *acoustical model*. One of the purposes of a numerical model is to evaluate measurements made in a practical situation. The other is to develop an experience base that is useful for extrapolation to future situations. He then discussed the details of the particular models he has been responsible for. Rathe said the models must be updated as new knowledge is gained and comparative measurements are made.

The last of the invited lectures dealt with the nonauditory effects of noise. This has come to the forefront in the last two decades, but still remains an open question. E. Ivanovich, Institute of Hygiene and Occupational Diseases, Sofia, Bulgaria, reviewed the field and discussed some of the epidemiological studies on the effect of noise on the cardiovascular and nervous systems.

Contributed Papers

Although Europeans presented most of the papers, there were several papers from the Middle East, Far East, Australia, and two from Canada. G. Rosenhouse, Technion, Haifa, Israel, and his students presented three papers. N. Peled presented one that dealt with a moving sound source in by a finite impedance wall. They showed computer calculations, using classical representations of the fields caused by a moving point source.

Rosenhouse and his student, R. Frances, coauthored another paper in which they discussed using iso-parametric finite elements for analyzing sound propagation near a ridge. This study used a hybrid formulation in which the bulk of the acoustical medium was represented using finite element techniques. At the same time, the ground boundary was represented using a boundary integral formulation. A similar approach has been used by D. Givoli, Technion, a former student of J. Keller (Stanford University). When I mentioned this to Rosenhouse, he was not aware of this work even though he and Givoli are at the same institution.

A. Adobes, A. Bouizi, and E. Luzzato, Electricite de France (EDF), Clasmart, France, discussed using finite-element methods techniques in an acoustical application. Here they applied it to the design of Helmholtz resonators. They claim that comparisons of numerical results with measurements on real resonator agree. In a conversation with Adobes, he confirmed that they had used this technique in analyzing the performance of sound absorbing masonry building blocks (SOUNDBLOX, based on a patent by M. Junger) used by EDF at their power station transformer sites.

F.P. Mechel, Fraunhoffer-Institut fuer Bauphysik, Stuttgart, Federal Republic of Germany (FRG), talked about sound propagation over absorbing ground. He again used this opportunity to point out that most papers on the subject present approximate results that are compared to other approximate results. Therefore, it is difficult to judge relative merits of the differing approximations. Although he purports to present exact numerical results here, he did not include them in the written paper, but he does refer to his forthcoming book. Although I have not seen the book, I assume that the results are included there.

G. Pavic, Electrotechnical Institute, Zagreb, Yugoslavia, discussed a practical measurement tool that allows for the localization of sound bridges (sound shorts) in double walls. His method does not require the measuring sophistication of methods using the intensity approach and provides a simple binary output; i.e., a *yes/no* answer, about a sound short in the measurement area. Using impact techniques, the existence of a short is recognized by noting sharp deviations in the resulting response wave forms.

T.M. Phan and P. Chipaux, Centre Technique des Industries Mécaniques (CETIM), Senlis, France, presented an example of the intensity approach. In this application, they showed the results of intensity measurements taken on an air compressor using an intensity measurement system developed at CETIM. This system employs a robot positioning system (Robot d'Intensite Acoustic du CETIM), a signal acquisition system, and a signal processor. They showed graphical displays of the output. This tool may be a way to evaluate noise control fixes for machinery noise.

D. Stanzial, E. Carlatti, and I. Vecchi, investigators from the National Research Council of Italy, proposed using acoustical intensity as a new tool for characterizing concert halls. The method should be complementary to reverberation time testing. They state that the direction of sound energy flow may be useful, but they do not say how it would be useful. The two latter authors also gave a paper that advocates using intensity to reduce agricultural machine noise emission. Here again, they show

results of intensity maps from specific objects or configurations with little indication of how to use this information.

Not unexpectedly, the most contributed papers came from Spanish investigators. Most were related to community noise surveys conducted in various cities and regions. As I have mentioned earlier, urban noise can be particularly bothersome there, and this was demonstrated on a more objective basis in several papers. One intriguing suggestion came from F. Daumal, a professor of architecture from Barcelona. He proposes the concept of an *Acoustical Park* where visitors can release their noise-induced stresses. The park would contain several architectural spaces where pleasant and tranquil sounds would be emitted, and concentrated, or focused at the listener. As an example, he cited the Garden of Paradise in Alahambra, Spain. This paper was imaginative and refreshing because it made creative and positive use of sound rather than report its negative aspects.

Conclusions

This meeting brought together scientists and investigators from more than 20 different countries. Most of the attendees were from European countries, with a much smaller number from Australia and Japan. After Spain, many contributors were from the FRG and France, with Italy very close behind. There were very few papers from the U.K., but I think one of the reasons for this was that the British Institute of Acoustics meeting had taken place earlier that same month. Evident throughout the course of the meeting was the European concern regarding the environmental impact of noise, and the desire to find ways to evaluate and alleviate this degradation of quality of life.

APPLIED MATHEMATICS

The Fifth International Symposium on Numerical Methods in Engineering

by David Feit

Introduction

On September 11-15, 1989, the Fifth International Symposium on Numerical Methods in Engineering was held at the École Polytechnique Fédérale de Lausanne (EPFL), Switzerland. This meeting, like its predecessors held in Versailles (1977), Montreal (1980), Paris (1983), and Atlanta (1986), was dedicated to the technology transfer in Numerical Analysis and Computational Engineering between the scientific and industrial communities.

Thirty-one countries were represented, but most participants came from either Switzerland or France. During my European travels, my impression is that the French scientific community is very heavily committed to numerical simulation both from theoretical and applied points of view.

At this symposium, scientists and engineers met who work in various aspects of computational physics and engineering. Here they exchanged ideas related to the approximate solutions of technological problems. The development of supercomputers in the last decade has paved the way for the numerical simulation of mathematical models arising from complex physical situations. As a result, these simulations lead to improved understanding of the underlying physics. These techniques have matured to the point where they now stand alongside the more traditional methods of theory and physical experimentation.

The papers presented at this meeting, included in the two-volume proceedings (R. Gruber, 1989), is a survey of the state of the art in advanced scientific computing as applied to engineering science. The meeting consisted of invited papers, minisymposia, and contributed papers over a wide variety of fields, including:

- Modeling - partial differential and integral equations, boundary conditions, macroscopic models, and cellular automata

- Numerical methods - finite elements, boundary elements, optimization, parallel and vector computing methods, domain decomposition, and multigrid

- Applications - nonlinear solid mechanics, fracture mechanics, composite materials, friction and contact, fluid mechanics, chemical flows, convection, free boundaries, combustion, and electromagnetics.

I listened to all of the invited papers that were presented at plenary sessions, and I will discuss some of these. Unfortunately, some of the more interesting ones were presented in French with no written version available. The contributed papers were presented in as many as five parallel sessions, over an enormous range of topics. Because of space limitation, I shall discuss only a few representative contributions that I found particularly interesting.

History and Background of the Venue

The meeting was opened by B. Vittoz, EPFL President, who gave a brief history of the institution on whose grounds the meeting took place. The EPFL was founded as a private school in 1853 and then became attached to the University of Lausanne in 1869 from which it separated in 1969. In 1977, the EPFL moved to its current modern campus at Ecublens, a nearby suburb of Lausanne. Today it is Switzerland's second largest school of technology.

When EPFL broke away from the university, it had 1,200 students; but now there are 3,500 with 1,800 staff members, including professors and researchers, many of whom are graduate students. The number of Swiss students has recently leveled off so that about one-third are externally (non-Swiss) funded. Also, about 35 percent of the faculty is from abroad.

The President took great pride that the school is training engineers who will be eligible for certification by the European Community (EC) of 1993. He also spoke of a large involvement in the European Atomic Energy Coordinating Committee (EURATOM) with the school contributing much activity in plasma physics. Also, they are involved in ECOTEK, one of 12 pilot technology centers throughout the EC, that is dedicated to studying flow turbulence and combustion.

Invited Plenary Lectures

Finite Elements with Drilling Degrees of Freedom. T. Hughes presented the first plenary lecture. F. Brezzi, Department of Structural Mechanics and the Institute of Numerical Analysis of C.N.R., Pavia, Italy; A. Masud, I. Harari, and T. Hughes, all of Stanford University, California, wrote the paper. This paper presented a finite element formulation which included drilling degrees of freedom. Drilling degrees of freedom allow for rotational motion about a normal to the plane over which an element is defined. Such a formulation is particularly useful in the analysis of shell structures and folded plates. The methodology presented allows any standard element to be generalized to include these drilling degrees of freedom. They proved that elements based on the theory converge. For the case studied (a cantilever beam of aspect ratio 4:1

with a parabolically varying end load) excellent accuracy results are demonstrated.

Spectral Superposition on Finite Elements for Shear Banding Problems. T. Belytschko, Northwestern University, Evanston, Illinois, presented a paper (coauthored with J. Fish) on using a superposition of spectral and finite elements for the problem of shear banding in a viscoplastic tensile specimen. Spectral elements use high-order interpolants for convergence rather than relying on finer domain subdivision. In this application, the spectral interpolants are superimposed on the finite elements in the regions of steep gradients allowing for a better resolution in the high-gradient region. This leads to an enhanced understanding of the failure process. The generality of the finite element methods in attacking complicated geometries is thereby retained, but it is enhanced by the convergence rates of the spectral method where it is necessary. Using such hybrid methods as described in this paper appears to be most appropriate and necessary in high-gradient problems, especially those occurring in solid mechanics.

Numerical Simulation of the Kinetic Equations of Physics. P. Degond and P.A. Raviart, Center of Applied Mathematics, École Polytechnique, Palaiseau, France, discussed this topic. In certain applications, continuum fluid models are too crude to describe the physics so one must resort to solving the kinetic equations to obtain quantitative results. The distribution function for the population of particles in phase space is sought. Because of the multiple dimensions of the problem (phase space with its six dimensions evolving as a function of time) and the many degrees of freedom required for conventional methods (such as finite elements or finite differences), even the largest supercomputers cannot handle the problems. This paper therefore advocates and reviews recent developments in particle methods that allow many current problems involving plasma physics and semiconductor devices to be handled at a reasonable cost.

Modeling of Solidification Processes. Researchers at the EPFL Laboratory for Physical Metallurgy are actively developing new technical alloys and the solidification processes involved in their manufacture. M. Rappaz presented a paper on behalf of himself and J.L. Desbiolles, J.J. Droux, A.F. Hoadley, and J. Rappaz on the mathematical modeling of the solidification processes occurring in fabricating metallic alloys. They utilize a large variety of processes that are all characterized by a transition from a liquid to a solid state. There are basically two different numerical approaches that were applied to numerical studies of the phase change problem. The "front-tracking" method is used for the solidification of fairly pure substances. The other assumes that the solid and liquid make up a single domain with a mushy

ill-defined interface. The modeling of the latter uses average quantities defined at each node of the enmeshment. Rappaz discussed the latter approach in detail. The paper describes the average continuity equations and the FEM formalism used to solve them. The principal difficulty with this approach is the mesh size requirements. These are driven by the velocity gradient ahead of the liquid isoline which changes continuously with time. Therefore, one would require a very fine mesh size throughout the domain or some sort of adaptive meshing procedure. The work presented was funded by two EC projects: (1) Cooperation on Science and Technology (COST) (see *ESNIB* 90-02:27) 504 - Modeling of Solidification Processes, and (2) European Research Coordination Agency (EUREKA) (see *ESNIB* 90-02:4) 155 - Applications of High-Power Laser Beams.

The Convergence Behavior of Some Iterative Solution Methods. The numerical solution of most problems arising; e.g., from the discretization of partial differential equations, ultimately reduces to the solution of large systems of sparse linear equations. H.A. van der Vorst, Delft University of Technology, the Netherlands, discussed the convergence properties of some iterative solution methods. He particularly discussed conjugate gradient, generalized minimum residual, and conjugate gradients-squared. The paper reviews the methods and describes them in an implementable manner. By this, he means a description in which vectors that are no longer required in the process are overwritten or redefined to save memory space.

A New Approach for Transforming Domain Integrals to the Boundary. The boundary element method (BEM) is used as an alternative approach to the finite element method (FEM) in the numerical solution of many problems arising in engineering analysis. A particular advantage of the BEM approach is the reduction of the problem to one over the boundary of the domain in question rather than over the volume, as would be the case for FEM, thereby leading to a reduction in the number of unknowns to be solved for numerically. However, in using the technique for time-dependent or nonlinear problems, cells internal to the boundary must be introduced, partially obviating the advantage.

C.A. Brebbia, Computational Mechanics Institute (CMI), Southampton, U.K., gave a plenary talk on a new approach for transforming the internal domain integrals to boundary integrals. Brebbia is a principal proponent and spokesperson for the BEM approach. The paper was written in collaboration with A. Nowak, CMI, who originated the Multiple Reciprocity Method (MRM), which is the basis for the present paper. The idea of MRM is to first obtain a sequence of higher-order fundamental solutions to the basic field equation to be solved. Then apply Green's identity to each term in the sequence, leading to a boundary formulation of the domain integrals. The paper applied the MRM technique to a Poisson-type equation, and used these results to treat a transient diffusion and wave equation as examples of the applicability of the method. Brebbia's presentation also included several interesting and apparently controversial remarks directed towards FEM practitioners advising them of the advantages of BEM. Surprisingly, no one in the audience took up the challenge for a mini-debate on the subject.

Mixed Formulation Revisited on Problems of Plates and Shells. O.C. Zinkiewicz, University of Swansea, U.K., talked (not in proceedings) on using mixed formulations for problems of plates and shells. Mixed formulations are those in which the equations governing different types of dependent variables are retained rather than reduced to equations on the same type of variables, but usually of higher order. In classical acoustics problems, this mixed formulation is one that uses the four first-order coupled equations (pressure and particle velocity) of momentum and continuity rather than the second-order wave equation on, say, pressure alone. According to Zinkiewicz, such an approach can generally lead to better accuracy, reduced continuity requirements, and the resolution of certain limiting difficulties such as that arising from the approach to incompressibility in acoustics, or the thin plate approximation in elastic plate theory. He points out that some finite elements are not "robust;" i.e., they do not work in all cases. He warned that one must be aware that commercial codes using such elements will fail ultimately in limiting situations.

Modèles de Propagation d'Ondes Elastiques. A. Bamberger spoke on propagation models for elastic waves. He presented the paper in French; it is not in the proceedings. In essence, he reviewed the procedures by which seismologists working in oil exploration use numerical simulation to analyze seismic recordings and conduct seismological exploration. Bamberger discussed the enormity of the computational tasks required by these applications and showed graphical illustrations of the results in representative cases. From the results shown, it becomes very understandable why the oil industry and its service organizations are among the biggest supercomputer users.

Contributed Papers

S. Karni, Cranfield Institute of Technology, U.K., discussed one-way absorbing boundaries for wave-like equations. These are necessary to truncate an unbounded physical domain by an artificial boundary to limit the computational requirements for the calculation of wave motion external to a vibrating body. Ideally, the boundary conditions should not give rise to reflected disturbances

in the calculated response. This is impossible to achieve in practice. This paper introduces the notion of a "sponge layer" which has the effect of slowing down and attenuating the outgoing waves thus preventing disturbances from reaching the artificial boundaries. The modifications for both one- and two-dimensional hyperbolic systems are demonstrated. These are introduced at the level of the governing partial differential equations and are therefore independent of the discretization method.

The session on electromagnetics included papers related to acoustics. L. Fishman, Colorado School of Mines, Golden, talked about symbol analysis and the construction of one-way direct wave propagation theories in ocean seismo-acoustics. This approach is complementary to the parabolic approximation used in solving underwater acoustic propagation problems for spatially varying sound speed profiles. In this report, he compares high-frequency results of the present theory with the rational function-based, high-angle, parabolic equation approximation.

The next paper in this session, devoted to wave propagation, demonstrated how the parabolic equation method was used to model electromagnetic propagation in the troposphere. M.F. Levy, Rutherford Appleton Laboratory, Didcot, U.K., presented the results. The parabolic equation solution reduces to a sequence of Fast Fourier Transforms (FFT) which is implemented on a personal computer. She showed several examples of the calculated fields for complex refractivity structures.

J.R. Mosig, Laboratory for Electromagnetics and Acoustics, EPFL, presented the final paper of this session. The paper dealt with the numerical analysis of microstrip planar antennas. A microstrip planar antenna is used to launch electromagnetic waves and is configured as a thin metallic patch on the surface of a flat dielectric substrate sitting on a ground plane. The mathematical problem is reduced to an integral equation on the boundary of the configuration and is similar to that occurring for an elastic plate underlying an acoustic halfspace when the plate has a nonuniform mass distribution and is loaded by a force distribution. The integral equation is projected over a set of test functions, and is thus reduced to a set of linear algebraic equations with a full matrix. The nonsparsity of the matrix is characteristic of boundary integral equation formulations. The surface current results for an L-shaped antenna are shown. The methods of solution and the approach presented are very much akin to methods used in structural acoustics problems related to flat plates with nonuniform mass and stiffness distributions.

Conclusions

This meeting brought together many of the world's experts in the numerical solution of engineering problems. The two-volume proceedings can stand as a partial survey of the state of the art in several very diverse fields. Because of the many different fields included, the only criticism I have is that no in-depth information is provided in any one field of application. Anyone wishing to get a flavor of what is happening in computational engineering would do well by perusing the proceedings of this symposium and its predecessors.

References

Proceedings of the Fifth International Symposium on Numerical Methods in Engineering, Vols. 1 and 2, eds. R. Gruber, J. Periaux, and R.P. Shaw, Computational Mechanics Publications, Southampton, Springer-Verlag, Berlin (1989).

BIOTECHNOLOGY

The Fifth International Conference of the Society of Applied Algology

by Dr. Keith E. Cooksey, the Liaison Scientist for Biochemistry, Microbiology and Marine Biotechnology in Europe and the Middle East for the Office of Naval Research European Office. He is Professor of Microbiology and Biochemistry at Montana State University and is on leave of absence from there until August, 1991.

Introduction

The Fifth International Conference of the Society of Applied Algology was held in Israel in January 1990. This conference, which attracted about 150 participants from 23 countries, was subtitled "Recent Advances in Algal Biotechnology." Later this year, "Biomass" will publish a selection of the papers presented.

Overview Sessions

The conference opened with two overviews of algal biotechnology presented by Professors Noel Carr, University of Warwick, U.K., and Amos Richmond, Desert Research Institute, Israel. Neither speaker considered we had proceeded far along the path to a successful algal biotechnological industry. Professor Carr is most well known for his work with cyanobacteria. He pointed out that the majority (if not all) of cyanobacterial cultures in use were isolated using photoautotrophic growth conditions. Therefore, we should not be surprised if their physiology is found to be photoautotrophic. This form of elective culture may miss all manner of organisms in nature that have mixed physiologies and ones that are capable of chemically modifying carbon compounds added to growth media; e.g., the ability to carry out biotransformations. Professor Carr did not tell us how heterotrophic or mixotrophic cyanobacteria could be isolated selectively. The ability of organic compounds to stimulate light-limited growth would probably be effective, however.

Because cyanobacteria are procaryotic micro-organisms and can harbor transducing cyanophages, they are more easily engineered genetically than higher plants. Therefore, it is possible that these cells could be induced to grow faster, rather than merely to repartition their photosynthate, as is the case in plants bred for agriculture by traditional means. Thus, these "algae" are particularly useful in biotechnology; however, up till now they have been under-exploited. Carr left us with the caution that the large-scale monoculture of any organism, even cyanobacteria, can lead to outbreaks of disease. This is even more relevant after recent papers documenting the widespread occurrence of cyanophages in natural waters.

Dr. Richmond's view was even more pessimistic than Carr's. Richmond considered that algal biotechnology, even after 40 years, had not left first base (his term). Nevertheless, there are about 12 companies worldwide that appear to be profitable. Even for these, the technology is not very advanced. Products such as health food (*Spirulina* sp.) are very precariously balanced in the economy, since their market is subject to human fashion. In any case, Dr. Richmond considered algal biotechnology to be too costly (given today's markets and the current products) to be economically feasible. This is particularly disturbing since Dr. Richmond is a leading figure in the field and thus is well informed. However, this is not to say that algal technology at the "village agricultural" level even now is unsuccessful.

Dr. Richmond's main reason for being so pessimistic concerning the future is that to obtain high levels of conversion of light energy into product, algal cells must be exposed to elevated light intensities. At such irradiances, photoinhibition usually takes place. This is probably one of the basic, perhaps *the* basic problem facing algal biotechnology with both proaryotic and eukaryotic cells and an area in need of much more research. Although much of the research on algae is performed ostensibly to promote technology in desert areas, apparently these areas are not particularly suitable for the production of algal biomass in open raceways--the most common form of growth system in use today. For instance, problems of diurnal temperature cycles and low humidity increase the need for costly temperature and evaporative control. The tropics, therefore, are far more suitable venues.

The take-home lesson from Dr. Richmond's work is that we must move towards more controlled and enclosed growth systems. This, in turn, means that low-value pro-

ducts dependent on biomass will not be economically feasible soon (e.g., biofuels). At the same time, algal biotechnologists should concentrate on producing high-value materials such as drugs or fine chemicals. In this regard, technology now exists to remove the "fishy-smell" from fish oils, so one of the main reasons for the production of ω:3 fatty acids from algae rather than fish oils now is lost.

Algal Biotechnology

Following the overview sessions, there was a session on the prime variable in algal biotechnology, light, and its use by algae. As referred to earlier by Dr. Richmond, photoadaptation; i.e., the changes in algal physiology as a result of altered light regimes, is of paramount importance in trying to carry out algal growth for industrial purposes. The problem, according to Dr. Zvy Dubinsky, Bar Ilan University, Israel, is that at low light levels algae are very efficient in converting light to chemical energy; whereas, at high light intensities, low efficiencies are recorded. So far, it has not been possible to utilize high light intensities efficiently.

If it were possible to interfere with the regulatory control of photoadaption, it may be possible to overcome the problem. This was the focus of the work described by Dr. Paul Falkowski, Brookhaven National Laboratory, New York. Dr. Falkowski is focusing on the control of the size of the light antenna; i.e., the number of functional chlorophyll $\underline{a}$ molecules per cell. Because chlorophyll apoproteins are degraded if not conjugated with a chlorophyll molecule, control at the level of their synthesis appears unnecessary. Various organizations throughout the world have funded research to improve photosynthetic efficiency of algae grown for biotechnological purposes. One strategy is to supply the light in flashes. The rationale is that it is the dark reactions of photosynthesis that are rate-limiting to productivity, not the harvesting of the photons themselves. However, the so-called flashing light enhancement of productivity is controversial. Dr. J. Grobbelaar, University of the Orange Free State, South Africa, tried to separate in a controlled manner, mechanical agitation of the culture, which, in effect, causes a cell in dense culture to experience a time-varying light regime, from a direct variation in light level. He was unable to show that changes in the length of light flashes (1-260 secs) caused clear-cut and consistent changes in productivity over control levels. However, as may be expected, mechanical mixing of cultures did influence productivity--probably became mixing-reduced, mass-transfer limitations. I have suggested previously that the removal of the inhibitory effect of dissolved O_2 on photosynthetic productivity may be relevant here. Supporting this idea was the poster by Dakhama et al., showing that algal growth was enhanced 5-fold by a negative pressure of 350mm.

Dr. L. Mur, University of Amsterdam, the Netherlands, discussed changing light/dark periods of a more normal scale. Dr. Mur reminded us that in a biotechnological enterprise, productivity is that increase in biomass produced over a 24-hour period. In other words, short-term rates are not that relevant, unless maintained over the diurnal cycle in outdoor growth/activities. Since long days produce high rates of dark respiration, and short days the opposite, there is a compromise light/dark ratio that maximizes productivity. For the *Oscillatoria* cells favored by Dr. Mur, the magic ratio is 16 hours light and 8 hours dark. Unfortunately, this day/night cycle is not available naturally in the tropical areas favored by Dr. Richmond for outdoor growth facilities.

Miscellaneous Presentations

The rest of the conference focused on papers concerned with using algae in producing fuels, β-carotene, astaxanthin, drugs, carbohydrates, health food, and fine chemicals. Also, there were communications concerned with equipment and using algae in waste-treatment ponds. I will discuss some of the papers that I consider most relevant.

There is really only one star in the list of products produced by algal biotechnology--β-carotene. Dr. A. Ben Amotz, Israel Oceanographic and Limological Institute, told us there are six companies worldwide that are involved in this process: one in Israel, two in Australia, two in the U.S., and one newly organized Anglo-Spanish company. The product survives economically because it is at least 50 percent the important 9-cis isomer; whereas, the purely synthetic form is 99 percent the all-trans isomer. This molecule can reach a level of 5 percent of the dry weight of the cell under optimal production conditions. The Israeli group in Haifa has done much to elucidate the points in the synthesis where structural isomerization is added to the molecule. Apparently, isomerization occurs before the phytoene synthetic step. They have mutants (produced by classical means) that accumulate up to 8 percent β-carotene in low light. These should be useful in dense pond culture. The role of β-carotene in preventing cancer is still not proven. However, doses of this compound recommended by cancer protection would require one to eat 2.6 kg of peas/day or 3-50 mg tablets of algally-produced material.

β-carotene is usually produced from *Dunaliella bardawil* or *D. salina* grown under highly stressed conditions (high light, very high salt) in man-made ponds. However, Dr. L. Schlipalius, Betatene Ltd., Australia, told us of his company's use of a natural lagoon of 300 hectares in South Australia. He referred to his process as *extensive* rather than *intensive* culture. The success depends, I think, on the ability of this company to harvest economically rather low density cultures of *D. salina*. This company sells its β-carotene for animal feeds, human dietary supplements,

and food coloring. Another, terpenoid pigment, astaxanthin, is formed by *Haematococcus pluvialis*, a freshwater alga. Again this compound, currently costing $1500/kg and produced by Microbio Research of San Diego among others, is a dietary supplement for maricultural species, especially salmon, the flesh of which is almost white without the supplement.

Dr. C. Sheshadri, Algal Research Center, Saveriyarpuram, India, discussed problems with the downstream processing of algal β-carotene and presumably astaxanthin. His figures for the losses of the highly reactive β-carotene on spray drying and storing emphasized the care needed in bringing a potentially unstable product to the market. This may explain why perhaps the Australian producers were so coy in avoiding questions concerning their downstream processing procedures. Several papers considered the growth conditions necessary for the synthesis of these secondary products of photosynthesis. In summary, any condition that allows photosynthesis but prevents algal cell division promotes the increase of these metabolites in the cell. In only one paper was there biochemical rather than physiological evidence presented supporting this (Thomas, Montana State University). Unfortunately, the meeting was characterized by a general lack of discussion of biochemistry. These bio-industries are still, in many cases, better termed maricultural, rather than modern biotechnological endeavors.

While some algae produce triglyceride or β-carotene when faced with physiological stress, others produce extracellular carbohydrate. Several authors presented papers on these. Products from the alga *Porphyridium*, Dr. Geresh, Ben Gurion University, Israel, explained, are used in the secondary recovery of oil and as drag reduction additives. The viscosity of the carbohydrate solution is pH dependent--a factor that can be exploited commercially. The *Porphyridium* polymers can be used also to enhance synergistically the viscosity of xanthans made from locust beans. Dr. Geresh said that the extracellular materials from *Porphyridium* were mixed heteropolymers and contained xylose, galactose, some methyl hexoses, glucuronic acid, and sulfate. L-galactose was found, which is unusual. Other workers presented papers on carbohydrate from other algae, but none of the research on the polymers described was at a sufficient level of advancement to give one confidence in the development of a new algal biotechnological product.

There were no reports of new antitumor drugs, but Dr. Yamaguchi, University of Tokyo, Japan, described a new inhibitor for angiotensin-converting enzyme that could be useful as an antihypertensive agent. The compound (a decapeptide) was found in *Dunaliella bardawil* and *Botryococcus braunii*. We must note that fortunately, the peptide is not a contaminant of β-carotene preparations.

In this vein, Professor Codd, University of Dundee, reminded us that although the cyanobacterial toxins that are found in drinking and recreational waters in the summer during algal blooms, are usually considered a nuisance, they could also be potentially pharmacologically valuable. After all, curare, once considered only as a deadly poison, is regularly used during open-heart surgery. It behooves us to look more carefully at this group of organisms; i.e., the gas vacuolate cyanobacteria, for further interesting compounds.

Only two presentations in this conference would have raised the interest of a potential algal "gene-jockey." In the first, a poster by Roth-Berjerano *et al*, Ben Gurion, University, Israel, showed that *protoplasts* of the red alga *Porphyridium* could be made using a crude extract of the algal predator, *Gymnodinium*. The cell wall of *Porphyridium* is highly complicated and is resistant to the more common carbohydrases. The regeneration of *Porphyridium* protoplasts was obtained, which opens the way for genetic manipulation of the alga, already useful for producing viscosity-enhancing extracellular carbohydrates.

Stevens, Memphis State University, presented the other paper. He has been able to put the toxic crystal protein genes from *Bacillus thuringiensis* into the freshwater cyanobacterium *Agmenellum* (*Synechococcus*). Dr. Stevens hopes that the alga will be a useful vector (in the non-genetic sense) for the crystal protein toxin that is stable in waters where mosquito larvae live. The balance of Dr. Stevens' paper concerned cyanobacterial pigments such as phycoerythrin and their use as fluorophores. Several clinical diagnostic companies now use these fluorescent molecules, the quantum yield of which are ten times that of fluorescein.

Several presentations described equipment to grow algae under controlled conditions. Most interesting to me was the reliance of one company on heterotrophic algal growth in what I surmise were former penicillin fermenters. The very property of algae that was of paramount importance; i.e., their ability to use light as a source of energy, now appears abandoned for the greater control offered by a closed container. Obviously, only a relatively few algae can be grown in this manner (see Dr. N. Carr's remarks).

If algal biotechnology is going to succeed, it must attract some of the more well-known biotechnological companies since small start-up companies cannot afford to do the necessary research, and governments are loathe to become involved. Representatives of Roche, The Nutrasweet Company, Japan NUS Company Ltd., Daimippon Ink and Chemicals Inc., attended the meeting, as well as representatives of several quite small companies. Possibly, the speakers who opened the conference were too pessimistic; perhaps there's a place for the small and usually green cell yet in biotechnology.

COMMUNICATIONS

International Implications of Open Systems Interconnect

*by J.F. Blackburn. Dr. Blackburn was the London representative of the Commerce Department
for Industrial Assessment in Computer Science and Telecommunications.*

Introduction

Perhaps the most important reason that Open Systems Interconnect (OSI) is receiving attention is its prospective role in harmonizing distributed computing systems. The convergence of the computer and telecommunications industry resulted from progress in microelectronics and the ability to process and transmit voice and images, as well as data, in digital form. Advanced communications networks today consist of interconnected computer systems controlled by sophisticated programs that carry all information in digital form. Program control of switching began in the late 1960s with, for example, the Bell System's Electronic Switching System, where information was originally in analog form. Voice transmission in digital form followed which made it possible to handle voice and data in the same transmission system. Of course, transmitting data in digital form had been happening for a decade in proprietary systems.

The OSI is a network architecture that will serve distributed computing systems, and can provide compatibility among complying systems. Also, it provides rules governing the transmission and interaction or interoperation of the various components of the system. Clearly, an architecture is needed because distributed computer systems have physical and logical components that require rules for their interoperating and interfacing with each other. The levels where such rules apply range from the microchip to network architecture. The network architecture provides a complete set of rules for connection and interoperation among the components, both physical and logical. The architecture includes specifications for providing and using services in a distributed computer system.

The seven-layer model for OSI architecture is needed to support peer-to-peer communication and interaction and to manage the complexity of the network architecture. While a separation of the whole complex operation into layers (different from that used in the OSI model) is possible and can be equally valid, a standard is needed to achieve the compatibility objective. Standard data ele-ments, a standard communication path, and required data conventions like format and transmission speed are needed.

To meet the needs of networks on an international level, OSI must allow for variations in communication practices in different countries and different regions of the world. For example, OSI must accommodate the European connection-oriented system and the U.S. connectionless system. There are other differences in practice that also must be considered.

There are differences between connection-oriented and connectionless communication. Consider the transport layer as an example. The function is to insulate the user from the actual network by allowing him to request a particular quality of service based on availability. To provide its service to the layer above, the session layer must communicate with the transport layer at the receiving end of the network, and then assemble the appropriate protocol message into a Protocol Data Unit (PDU).

The transport layer constructs a primitive containing the PDU in a user data field called a Service Data Unit (SDU) for the Network Layer (the layer below). Besides PDU, SDU contains request for transport of SDU across the network. The network layer then applies the appropriate procedures to form a PDU to the network layer unit at the receiving end. The SDU (PDU from the transport layer) remains intact and becomes the user data field of the new PDU.

In the above example, the connection mode assumed that a connection had been established. This mode ensures that any PDUs transmitted by one entity can be received and intelligently interpreted by the other, through providing sequencing and tracking of each PDU in the set of PDUs that make up the message. Sequence numbers are assigned to each PDU.

In the connectionless mode, no previous connection exists and PDU arrives at the receiving end of the network with no indication that it is a part of a sequence of PDUs. The PDU carries the receiver's address, but no sequence number. In this mode, the PDU sequencing and trans-

mitting of error recovery is performed by a connection mode protocol in a higher layer.

Detailed implementation profiles must be developed that can interface with profiles developed in other countries or other locations. For example, the U.K. Government Open Systems Interconnect Profile (GOSIP) and the U.S. GOSIP will be able to interact, as required, through gateways. However, their detailed implementations will be quite different because of the connection-oriented versus connectionless modes of communication within the two systems, as well as other possible internal differences.

Another important matter is computer availability and communications products that implement OSI properties. Computer manufacturers must produce the myriad of products needed so that OSI is accepted and implemented worldwide. American, European, and Japanese companies have made much progress in this area. However, the need for products has not been fully met.

Several important government efforts are underway to meet the systems needs in the implementation of OSI-based networks. In the following paragraphs, I summarize the work underway for OSI profiles, including U.S. GOSIP and U.K. GOSIP. Also, I discuss British Telecom Open Network Architecture (ONA).

U.S. GOSIP

In the U.S., the National Institute of Standards and Technology (NIST) is responsible for the specific combination of OSI protocols that define services and functions needed for communications tasks. These services and functions will be included in GOSIP. The U.S. Government will need a large computer network over the next decade. This need represents an enormous market. During the 1990s many such networks, each including thousands or even tens of thousands of workstations and terminals performing common applications, will be implemented. The U.S. Government represents a $17-billion market for the computer industry. For fiscal year 1990, the Department of Defense expects to spend over $8 billion for data processing equipment and services. Contractors to the U.S. Government who must communicate and interact with Federal agencies represent another $10 billion.

The U.S. Government is committed to OSI. As an example, the Federal Aviation Authority (FAA) awarded the procurement of a new air traffic control system in August 1989 to IBM (estimated value - $10 billion). The system will include thousands of computers interoperating over a network, requiring high performance and high availability. The FAA mandates that OSI be used throughout the system.

As the FAA flight control system begins operating by the mid-1990s, other systems in the U.S. and other countries must interoperate with it. These systems will include equipment designers providing information to flight control systems. Commercial organizations must interoperate with flight control systems of other countries. To achieve this interoperation, OSI must be part of other systems' architecture.

Through standardizing computer systems procurement around GOSIP, the U.S. Government will achieve enhanced interoperability of its computer systems, regardless of manufacturer. This interoperability will be achieved without losing any services or changing local interfaces.

New services will also become available, including directory capability, dynamic routing, network security, network management, and office document architecture and interchange. However, some of these new services will be available after full OSI network management standards are completed in 1994.

Local area networks (LAN) and wide area networks (WAN) will be more consistent by using GOSIP. Through OSI, a logical (rather than physical) network address structure is provided as required in present network systems. The GOSIP also provides standards for specific media and interfaces for computer-to-computer interconnection.

Furthermore, GOSIP will make possible platform independent, object-oriented applications based on reliable end-to-end transfer capability. Thus, GOSIP will assure interoperability of present day network computers with future generations of computers, which will permit upgrading without losing previous work.

Clearly, the government's successful implementation of GOSIP as a single networking architecture for all Federal agencies will cause many important changes in computer networking. The implementation also will have a strong impact on computer vendors and private sector computer users throughout the world.

Based on earlier workshop efforts, NIST began developing a U.S. government profile in 1986, and had a draft specification available in December 1986. After review, revision, and approval by the Secretary of Commerce, it became a government procurement standard-- Federal Information Processing Standard (FIPS) 146. This version became effective February 1989, and becomes mandatory in August 1990. The Department of Commerce released a draft Version 2.0 for review in April 1989.

For U.S. GOSIP, the government has mandated using a single transport class (Transport Class 4 [TP4]) and a connectionless network layer protocol. The U.S. GOSIP provides for X.25 (running under TP4), token bus, token ring, and Ethernet as network technology for LANs and WANs. The U.S. GOSIP also specifies that Intermediate

Systems (IS), commonly used in routing applications, should run in connectionless mode.

Through the above mandates, the government wants to assure interoperable data transfer covering many different applications, and running over a variety of network technologies based on products from a variety of manufacturers. The government wants both interconnection and interoperability.

Two upper-layer applications are specified by GOSIP: File Transfer, Access, and Management (FTAM), and Message Handling System (MHS). The functional units to support the upper-layer applications are provided in the session layer. Abstract syntax notation number one (ASN.1) facility is needed in the presentation layer.

The full purpose FTAM system provides positional file transfer, simple file access, and management. A limited purpose FTAM supports is simple file transfer and management. Most early implementations will be of the latter category.

As GOSIP specifies the 1984 X.400 MHS, which mandates Transport Class 0 (TP0) and the connection-oriented network service, the GOSIP message transfer agent (MTA) (part of the MHS application) performs the relay between the TP0-based public network and the GOSIP TP4-based system.

A major advantage of GOSIP will be handling large networks as well as small ones. In most existing networks, problems arise with growth. For example, the transmission control protocol/internet protocol addressing scheme encodes a network name and a host on the network. However, the address only specifies a connection to the host. The address has a direct relationship to the physical layout of the network, which leads to difficulties for relocating users for subnetwork growth and for routing traffic management.

The OSI addressing techniques included in GOSIP are more object-oriented than in earlier systems. The network name denotes an entity that may be translated through a dictionary into an address. Directories at the application layer identify application titles and network layer service access point (NSAP) addresses at the network.

Based on the above scheme, an application on any machine on the network can be reached through one address--its NSAP address. Directories are used to convert network names into specific address assignments. The OSI addressing requires neither physical information about the network nor routing information to be contained in the address.

The OSI also provides for a global addressing idea, using hierarchical network addressing. The OSI addresses in NSAP specify a domain where the address may be divided further by the domain administration.

Version 2.0 of GOSIP will provide some additional functionality including Virtual Terminal (VT), Office Documentation Architecture, Integrated Services Digital Network, End System-Intermediate System (ES-IS) protocol, Connectionless Transport Service, and Connection-Oriented Network Service.

U.S. GOSIP is part of a wide effort to develop computer standards within the federal government. Other initiatives include the Ada Common Software Initiative, the Portable Operating System Interface (POSI), and the NIST Application Portability Profile.

As stated earlier, GOSIP initiative will have a major impact throughout the federal government, but also throughout the private sector. The private sector response to GOSIP is quite positive.

U.K. GOSIP

U.K. GOSIP was developed to:

- Facilitate procurement and acceptance testing of communications-based products
- Ensure that different and separately procured departmental systems can interwork to an assured level of functionality
- Provide a clear specification to manufacturers to base strategic product development.

U.K. GOSIP is a selection of particular OSI protocols for the U.K. Government administrative information technology (IT) services. U.K. GOSIP complements existing programs of functional standardization and assists the user lacking the resources, or not sufficiently skilled to choose among the optional elements within the OSI functional standard. In addition, it provides further procurement advice.

The system will follow the development of other functional standards and profiles, based on OSI, where the requirements are compatible with the U.K. Government, including:

- European functional standards being developed by the Comite Europeenne de Normalisation/Comite Europeenne de Normalisation Electronique (CEN/CENELEC) and Conference Europeenne, Postal et Telecommunications (CEPT) under the direction of the European Commission and based on earlier work by the European manufacturer consortium, Standards Promotion and Applications Group (SPAG)
- British Telecom's ONA profile
- NIST's implementation agreement
- General Motors Manufacturing Automation Protocol (MAP)
- Boeing's Technical and Office Protocols (TOP) initiated in U.S.

- U.S. Corporation for Open Systems (COS) protocol stacks which are primarily intended for the development of testing services

- Development of GOSIP-equivalent for the U.S. Government and similar intentions in other national governments

- Anticipated development by ISO of International Standardized Profiles (ISPs).

The Central Computer and Telecommunications Agency (CCTA) is responsible for the U.K. GOSIP development. This agency will maintain close liaison with all of the above activities to achieve as much commonality of approach and options as practical at the layers of the OSI model. If a departmental requirement exceeds the GOSIP specifications, the CCTA will advise on suitable modifications or additions. The CCTA will also provide support for interworking with existing OSI-based systems, and advise on product availability where GOSIP anticipates supplier development. Although the initial GOSIP specification has dealt mainly with standards for products that may be procured soon, some areas of specification anticipate product availability to a greater extent, but may stimulate product development. Many areas of the specifications will be further enhanced to provide greater flexibility. In all cases, the critical issues of migration and interworking between different subprofiles and versions will be considered.

U.K. GOSIP architecture defines three subprofile groups: transport, application, and interchange formats and is similar in most respects to U.S. GOSIP. However, the U.S. GOSIP's NSAP addressing extensions are not included in the U.K. GOSIP. Thus, the two systems will only be able to interoperate through gateways.

Another lower layer difference is the use of TP0 service in U.K.: GOSIP for End System (ES) to Intermediate System (IS) communication and IS to IS communication. In the latter case, public packet switching networks may have dynamic routing provisions for LAN connectivity. This is because packet-switched network connections are more common in the U.K. than in the U.S.

In the application layer, U.K. GOSIP provides the services: FTAM, MHS, and VT. U.K. GOSIP has a modification of the FTAM European functional profile standard adopted by SPAG. The MHS subprofile of U.K. GOSIP for interoperability is based on the X.400 recommendation of 1984. The subprofile assures compatibility with British Telecom Gold 400 public mail system.

For its terminal support, U.K. GOSIP will use a definition applicable to an administrative environment concerned with character-oriented data entry and with data retrieval. The U.K. GOSIP VT profile is based on a paged-style Virtual Terminal Emulator (VTE) profile. Three interchange formats were chosen for U.K. GOSIP:

Government Documente Application Profile (GDAP), Simple Messaging Profile (SMP), and Electronic Data Interchange (EDI).

International Alignment of Government OSI Profiles

The International Public Sector Information Technology (IPSIT) Group is an informal arrangement among government organizations responsible for developing Open Systems procurement profiles. After examining the profiles developed by several governments, it has found that these profiles are fairly well aligned. The main difference is the two versions of Network Service and Transport class combinations. This refers to the use of TP0/2/4 in layer 4 and Connection Oriented operation in layer 3, for the connection-mode variant and the use of TP4 only in layer 4, and Connectionless operation for the Connectionless-mode variant. However, the IPSIT Group believes that interoperability can be achieved using available vendor products.

For a store-and-forward message application, such as electronic mail, MTA relays provide a natural way to bridge any difference at the lower layers. For applications that require direct end-to-end services, such as FTAM, the application layer relay approach is less appropriate. In such cases, commonly available vendor products can be combined to achieve application layer end-to-end connections in a variety of networking environments. Two variants of Transport class and Network service are available from commercial vendors of OSI products. Furthermore, a vendor will usually offer both variants at little or no additional cost over the price for one variant. Therefore, the IPSIT Group concludes that a variety of interoperability arrangements can be constructed from available products.

The IPSIT Group thinks it is unlikely that satisfactory interworking between Connection Oriented and Connectionless environments will be achieved. Therefore, it is recommended that users use the same mode of operation over LAN and WAN subnetworks wherever possible in the following ways:

- Use TP0 and Connection-Oriented operation for efficient interworking between end systems that are directly connected to a sufficiently robust Connection-Oriented subnetwork

- Use TP4 and Connectionless operation for interworking between end systems when at least one of the communicating end systems connects directly to a LAN and when Connection-Oriented operation is unavailable on the LAN, using Connectionless relays at Network Layer for LAN/WAN interconnection.

- Endorse and encourage the development of Connection-Oriented operation for LANs and, hence, enable the use of Connection-Oriented relays at Network Layer for LAN/WAN interconnection.

However, there is an interim interworking problem between an end system connected to a Connectionless LAN and an end system connected to a WAN that does not support Connectionless. The IPSIT Group suggests two solutions to this problem:

- Augment the Connection-Oriented WAN system to support TP4 and Connectionless
- Use a Connection/Connectionless Transport relay.

British Telecom's ONA

British Telecom has developed an ONA that provides a total approach to specifying, implementing, and managing IT products and internal systems. The system is well documented, and the documentation shows how ONA relates to other developments of users and suppliers. The ONA and U.K. GOSIP are aligned where they share common scope.

British Telecom lists the following benefits of ONA specifications:

- Allow British Telecom products to interwork with similar products or services, regardless of the supplier. For information on the relationships between ONA and other international and functional standards, see ONA TD0005 Part 1
- Ease the migration path between existing and new or additional products or services
- Provide common specifications and specification techniques for the procurement of different products and services, and an unambiguous basis for product and service implementation
- Ensure that procurers can recognize those implementations that conform or not to ONA specifications
- Backed by conformance testing resources which will confirm product and service conformance with the specification.

The scope of ONA covers the following areas necessary to achieve multivendor systems integration:

- Open system communication architecture for communication between disparate systems
- Application programing interfaces, which provide a consistent interface between software applications and the underlying system
- User interface, which provides a consistent design for human users across a range of products and services

- Information architecture and application environment to enable the users to maximize the value of their investment in software and data
- Cabling and wiring to underpin the communications architecture
- Security, name, and address issues common to all those environments
- Management architecture to develop a coherent approach to the management of multivendor systems
- Support services such as conformance testing, accrediting, and consulting
- Generic products to ease architecture adoption.

Implications

If the widespread implementation of the OSI systems meets performance expectations, its international impact will be enormous. Some of these expectations include:

- Effective interoperation of systems widely distributed. This could mean that a workstation in Paris could access a supercomputer in London and interoperate with it without transfer of data or programs from the supercomputer to the workstation. In other words, the workstation in Paris would need to interoperate with the supercomputer as if it were at the same location as the supercomputer. This would require very high bandwidth communication capability.
- Ease of use. Use of the system should not be so complicated that the user would have to have a detailed understanding of the architecture of the workstation, the supercomputer, and the network.
- Acceptable cost. The cost of interoperation would have to be competitive with the cost of doing the work some other way.

If the widely implemented OSI systems meet performance expectations, then there will be several favorable implications, some obvious and others not obvious. Using OSI will greatly simplify information exchange between users. The systems will facilitate development strategies and, the accommodation of organizational changes in large and small international companies and other international bodies.

Users of OSI systems will have a wider choice of equipment suppliers. This is advantageous for several reasons: (1) no single supplier can meet all the equipment needs of computing and communications systems; (2) users want to make independent choices in acquiring system components, rather than relying on a single vendor for everything needed in the system. Large international companies often will find it convenient or profitable to acquire equipment from different suppliers in different

locations or in different countries. Such worldwide user initiatives as GOSIP, MAP, TOP, European Manufacturers Users Group (EMUG), and OSITOP indicate the commitment of users to the OSI concept. In response, suppliers have indicated their support through organizations like SPAG in Europe, COS in the U.S., and POSI in Japan.

Worldwide systems that require active and continuous interaction throughout their extent, like airline reservations and air traffic control, will profit in many ways from compatible systems. Such systems will be more cost effective over the long run and operation will be greatly facilitated. As a result, safety should also be increased.

In both the computer and communications industries, product development will be better defined from the beginning because of the commonality of the interfaces and the functions to be performed. There will, of course, be differences among products from different manufacturers regarding implementing functions in their particular equipment.

This commonality of function among products will make the jobs of sales and service easier and will also simplify the users choice of products. The user will then base his choice on product cost, speed, and reliability. Having a common user interface for products, of whatever manufacture, will also benefit the user because he will only have one such interface to understand for a given product. The widespread use of OSI products will facilitate the combining of companies. Likewise, joint company efforts in research and development will be easier.

From the company's point of view, the difficulty will be achieving product differentiation. What the product will have to do may be very well defined. The product supplier must be concerned with speed, accuracy, reliability, and availability, as well as cost. The widespread adoption of OSI may result in fewer worldwide manufacturers of certain mainstream products, like supercomputers and large mainframe computers, and in switching systems in communications.

Choice of products by the user will be guided by investment cost, confidence in the supplier's longevity, performance, reliability, and availability of the product, and maintaining continuity in his operations.

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COMPUTER SCIENCE

Computer Science in Lisbon

by Robert D. Ryan, a mathematician currently serving as a Liaison Scientist for Mathematics and Computer Science in Europe and the Middle East for the Office of Naval Research European Office. Mr. Ryan is on leave from the Office of Naval Research Arlington, Virginia, where he is Director of the Special Programs Office.

Introduction

This report focuses on computer science in Lisbon; it also has some general observations about science and engineering in Portugal today.

In February 1990, I attended a meeting on neural networks held at Sesimbra, a fishing village near Lisbon (see this issue, page 19). I used the occasion to visit scientists at two of the main centers for engineering education and research in Portugal-- Instituto de Engenharia de Sistemas e Computadores (INESC) and Instituto Su-

perior Técnico (IST). My host at INESC (pronounced ineshk) was Dr. Luis B. Almeida, who heads a group in speech. He arranged for me to meet with several professors and graduate students at INESC.

Background

There are three main universities in Lisbon. The University of Lisbon established in 1290 is the "classical" university. This is where one studies law, languages, and medicine. This school has played an important role in

Portugal's history. By the mid-sixteenth century the University of Lisbon had become such a cultural and political power that it was a threat to the crown. The situation came to a head in 1547 when King João III quashed the University and moved it to Coimbra. Later João III gave control of education to the Jesuits. The University of Lisbon was refounded in 1911. In spite of the University of Lisbon's importance, from the earliest times, wealthy students preferred to study abroad. Generations of Portugal's leading theologians, doctors, and lawyers went to school abroad, mostly in England, France, Germany, and Italy. I have the impression that this is--or until recently was--still the case. Most of the university people I met had studied in the U.S. or in England. I observed that several of the senior engineering faculty had studied at Imperial College London.

The IST was founded in 1911 as a school of engineering. This followed in the wake of a popular revolution in 1910, which had ousted the last of the monarchists. The new Republic was eager to modernize education along with industry and transportation. The Technical University of Lisbon, the second of the major universities in Lisbon, was founded in 1930 to give university status to several technical and professional schools including the IST, the school of veterinary medicine, the agronomy institute, and the economics institute.

The third major university is the Universidade Nova de Lisboa or the New University of Lisbon. This university was formed in 1973 and is located south of the old city, across the river Tejo. The New University has around 7,000 students, while the University of Lisbon has about 20,000 students. The Technical University has near 15,000 students, 6,000 of whom are at the IST.

Two political events set the stage for the phenomenal growth in research and development (R&D) that one sees in Portugal today--The Revolution of April 25, 1974, and Portugal's entry into the European Economic Community (EEC) in 1986. The bloodless revolution led by a group of young army officers ended Europe's longest dictatorship and paved the way for stable democratic government. This did not come about immediately. Between 1974 and the early 1980s Portugal went through politically turbulent times, with 16 short-lived governments in the 13 years following the revolution. As the world economy improved in mid-1985, so did the economic and political climates in Portugal. Entry into the EEC in 1986 completed the foundation for continued democratic government and economic expansion. Membership in the EEC gives Portugal important trade privileges, development money, and research funds. More important for the long run, membership in the EEC is forcing Portugal's industry and agriculture to either modernize or go under in the face of European competition.

By all accounts, Portugal is responding well to the challenge. The signs are in the right direction. The gross domestic product increased by about 5 percent in real terms in 1989, and it is expected to do about the same in 1990. Portugal's investment in machinery and equipment grew in 1989 by about 9 percent over 1988. Investment in construction rose by more than 11 percent. Portugal's young private banking sector had a year of strong growth in 1989, benefiting from the high level of economic activity in the country with record foreign and domestic investments and from the government's privatization program. All of this economic and political optimism is reflected in growing research activity.

The demand for higher education in Portugal is strong. This, combined with a fixed number of openings at the state universities, creates keen competition for the free state education. In fact, the demand for education is so great that private schools, with less rigorous standards, have appeared. In Portugal, it is still the case that many of the best students elect to study science and engineering as well as law and medicine. The engineering schools have no problem attracting good students.

INESC

Until about 1980, the universities in Portugal were closed institutions, operating independently of Portuguese industry and business. They received little money for research from the state. Support for research centers was independent of results. This is not to say there were not talented, well-educated people in the universities, but that research support was low and there was little incentive to produce. Historically, people with PhD degrees took university jobs. These were lifetime, state-supported positions. Research centers like INESC are changing this.

Professor José M. Tribolet started INESC in 1980. Professor Tribolet had returned to Portugal and the IST after receiving his PhD in electrical engineering at the Massachusetts Institute of Technology (MIT) and spending a year at the Bell Telephone Laboratories. The origins of INESC are rooted in a single, initial contract that Tribolet had with the Army in speech encryption. This first contract brought in money from outside the university system and opened a new way to fund research in Portugal. Tribolet was able to buy computers and hire graduate students. This initial contract and Tribolet's vision has led to the development of one of Portugal's most important research centers.

Formally, INESC is a private, nonprofit distributed association (corporation) dedicated to R&D in advanced technological areas. The INESC was created to act as an interface between Portugal's telecommunications and information technology sectors and the Portuguese university system, which for practical purposes means between the telephone company and IST. The founding members of INESC were Correios e Telecomunicaçes de Portugal,

Telefones de Lisboa e Porto, IST, and the Universidade Técnica de Lisboa. In 1984, the Companhia Portuguesa de Rádio Marconi and the Universidade do Porto became members, and in 1987 the Universidade de Aveiro became an associate member. The Universidade de Coimbra and the Instituto Politécnico de Setúbal are linked to INESC through collaborative agreements.

There are 670 people working at INESC today, 10 years after its beginning. These include about 55 PhDs, 250 graduate students in Masters or PhD programs, and 325 senior undergraduates--all involved in research.

The INESC has three locations--Lisbon, Porto, and Coimbra. Most of the people are at the headquarters in Lisbon, located across the street, behind IST. The senior scientists at INESC hold positions at their respective universities; thus, the people at INESC in Lisbon have positions at IST.

There are several incentives for being associated with INESC: exposure to good problems, working with a group of people with similar interests, a cadre of good graduate students, and the support structure, including computers. Perhaps most important, INESC provides a vehicle for attracting money from outside the university. My hosts made it clear that the people at INESC are rewarded for good work, and that they can thereby increase their income over the fixed state university salary.

These are the current R&D areas at INESC:

- Modernization of the National Telecommunications Network
- Narrow Band Integrated Services Digital Networks
- Broadband Integrated Services Digital Networks
- Electronic and Microelectronic Technology
- Optical and Optoelectronic Technology
- Digital Signal Processing
- Computer Science
- Computer Engineering
- Information Systems
- Computer-Aided Design and Graphic Engineering
- Software Engineering
- Decision Support Systems
- Energy Management Systems

The INESC receives considerable support from the European Community (EC), through European Strategic Programme for Research and Development Information Technologies (ESPRIT) and through other EC sources. For example, the Social Fund supports the education of about 500 technicians a year at INESC. I count that INESC is currently involved in 25 ESPRIT projects and 2 ESPRIT basic research actions.

In 1989, people at INESC published 38 papers in journals or proceedings and wrote another 98 reports.

Computer Science at INESC

Professor Amílcar Sernadas, who briefed me on the computer science activity at INESC and in Portugal generally, is the force behind computer science research in Lisbon. He created the Lisbon Computer Science Group (Group) in 1981 at the Faculty of Sciences in Lisbon. The Group moved to the Department of Mathematics of IST in 1986. In the meantime, they joined INESC, which is the center for most of the activity. The Group focuses on theoretical computer science emphasizing symbolic systems, namely formal (logical, algebraic, and categorical) concepts, techniques, and tools for systems specification, design, and verification.

The research is done under one of the following projects:

Is-Core. This stands for Information Systems-Correctness and Reusability and is the ESPRIT Basic Research Working Group (Working Group) 3023. Professor Sernadas is the coordinator. The other participants in this Working Group are the Technical University of Braunschweig, Federal Republic of Germany (FRG), the University of Dortmund, FRG, Imperial College London, U.K., and the Catholic University of Tilburg, the Netherlands. The objective is to explore the methodological foundations of information systems design, with the intention of achieving provably correct systems and higher levels of reusability by using formal, object-oriented design techniques. According to the object-oriented approach, the information system is seen as a community of interacting objects. Some are passive like database records and some are active like database transactions. The Working Group sees this object orientation as essential for achieving more easily maintained information systems whose components are reusable and for developing techniques for designing large-scale information systems.

Oblog. This is a joint venture with Espírito Santo Data Informática (a large Portuguese financial group) aimed at the development of a workbench supporting the object-oriented formal specification and implementation of information systems. The envisaged workbench will provide for full multipresentation, prototype generation (via specifications animation), operational code generating and testing, all according to the Oblog methodology. Cost of the R&D and implementation of the operational system is estimated at $20,000,000.

Normlog. A contract with the Portuguese-American Foundation for Development is the source of funds for this project. The goals are: (1) developing tools for designing information systems based on the laws (as in legal) and other norms regulating their operational environment; (2) gradually developing a working team of Computer Science and Law experts to work on the prob-

lem of knowledge representation for the law and judicial proceedings.

ObMan. This project is part of a larger INESC initiative to develop an integrated multimedia workstation. Financed by the Portuguese Agency for Research and Development, the computer science group is developing an object manager over the uniform memory manager.

Knowlog. This is an effort in the area of the algebraic and categorical foundations of knowledge representation and conceptual modeling in the large.

Infolog. This effort extended from January 1983 through December 1985. I mention this older work because it was one of the first university-industry cooperative efforts in Portugal, which until recently was not part of the Portuguese academic culture. The research produced a methodology for information systems and database design that is now widely used in Portugal. In addition, it provided the basis for the current Oblog project.

Other computer science research at INESC and IST includes hardware work for highly parallel machines with Dr. Delgado; neural network research and distributed operating systems with Professor Alves Marques; artificial intelligence (AI) at IST with Professor Pavao Martins; and theoretical computer science in the mathematics department at IST.

Computer science at INESC has a strong object-oriented inclination, led by Amílcar and Cristina Sernadas. Both took PhDs at the University of London in 1980--Amílcar in computer science and Cristina in statistics. Other senior members of the group are José Carmo, PhD computer science, Lisbon 1988, and José Fiadiero, PhD computer science, Lisbon 1989. They are often joined by visiting scientists, including in recent years, H.-D. Ehrlich, Gunter Saake, and Joe Goguen. The group has published over 35 papers since 1985. There have been three PhD theses and 11 MSc theses from the group since 1984. Ten graduate students are currently working in the group.

Computer Science at Other Schools

I did not have the chance to visit other schools in Portugal, but my hosts at INESC described the following research activity:

The New University, Lisbon: Logic programing and AI, Professor Luis Moniz Pereira.

The University of Coimbra: AI techniques for control systems, emphasizing big plant applications such as paper production, Dr. Ernesto Costa.

The University of Porto: Emphasizing AI, Dr. Luis Damas (an expert on implementing Prolog), and Dr. Filgueiras in natural languages.

The University of Braga: Theoretical computer science, formal specifications, prototyping, VDM, Professor Valença.

Summary

Scientific research in Portugal is a growth industry, as it is in Spain and Ireland. The reasons are the same-- stable government and membership in the EEC. Computer science in Portugal reflects this trend. While EC support through ESPRIT and other Framework programs is very important, it is not the only EC support the INESC receives. For example, INESC receives EC support from the Social Fund to educate about 500 technicians per year, who then go to work for IBM, DEC, Hewlett-Packard, and the Portuguese banking and insurance industries. Other EC support for Portuguese industry also finds its way into research at INESC.

One gets a feeling of real excitement and optimism while visiting INESC and IST. There is no question that quality work is being done at INESC, particularly in the area of object-oriented thinking for languages, databases, and systems specification. These academics are having a strong influence on the direction of developing and implementing systems in Portugal. But success brings its own problems. A few years ago, INESC was practically unique as an employer of research scientists in certain fields. Economic growth, and with it the growth of the research enterprise, has created more opportunities for talented people. Whereas in the past INESC could choose personnel, they now face a problem in recruiting the best people. Nevertheless, one senses that Portugal is entering a new age of research exploration, an intellectual parallel to their 15th and 16th century age of discovery.

European Association for Signal Processing Workshop on Neural Networks

by Robert D. Ryan, a mathematician currently serving as a Liaison Scientist for Mathematics and Computer Science in Europe and the Middle East for the Office of Naval Research European Office. Mr. Ryan is on leave from the Office of Naval Research Arlington, Virginia, where he is Director of the Special Programs Office.

Introduction

The European Association for Signal Processing (EURASIP)-sponsored workshop on neural networks was held in Sesimbra, Portugal, a fishing village near Lisbon, February 15-17, 1990. The workshop's cosponsors included the Instituto de Engenharia de Sistemas e Computadores (INESC), Fundação Luso-Americana para o Desenvolvimento (a Portuguese-American organization), and the Portuguese Section of the Institute of Electrical and Electronics Engineers (IEEE). Luis B. Almeida, INESC, was the conference chairman and Christian J. Wellekens, Phillips Research Laboratory, Belgium, and Bellcore, New Jersey, was the technical chairman. About 60 people participated, mostly European; there were only 7 Americans, including the two invited speakers and me.

Twenty-one papers were presented in addition to the two invited talks. These are in the Proceedings (Almeida et al., 1990), which were available at the beginning of the workshop. Two afternoon poster sessions attracted 19 contributions. These poster papers do not appear in the Proceedings. Because the Proceedings are readily available, I will review only the invited talks and the 11 papers dealing with theory and algorithms. The titles and authors of the other 10 papers are listed for completeness.

Invited Talks

Although European participants outnumbered Americans at this workshop, both invited talks were presented by Americans.

How Can Learning Algorithms Generalize From Examples?, Eric B. Baum, NEC Research Institute, Princeton, New Jersey. Note that the title of Baum's talk differs from the title of the paper in the Proceedings, which is "When Are k-Nearest Neighbor and Back Propagation Accurate for Feasible Sized Sets of Examples?" However, the first part of the paper includes the subject of the talk. The theme was the analysis of how many examples are necessary for training a feed-forward neural network under the assumptions that the examples can be successfully loaded, where an example is loaded if, when one presents the example to the input of the network, the output of the network is the correct classification. The

setting for this work is the *Probably Almost Correct* (PAC) learning model introduced by L.G. Valiant in 1984 (Valiant, 1984). In this model, one assumes that examples are drawn from a distribution D over some feature space such as R^n or $\{1,-1\}^n$, for example, and are classified according to a Boolean target function f, where f belongs to some simple class F of Boolean functions. The central issue is: Is there an algorithm A that can look at examples and return, in polynomial time in n, ε^{-1}, and δ^{-1}, a hypothesis h such that h will with probability $1-\delta$ correctly classify at least a fraction $1-\varepsilon$ of future examples drawn from D. To paraphrase, the learning algorithm A is PAC in the sense that A generates a classifier h that, with confidence $1-\delta$, makes errors at a rate less than ε.

Two classes of Boolean functions entered prominently into the talk: F_1 is the class of half-spaces defined by

$F_1 = \{f: f(x) = 1 \text{ if } w \bullet x - t > 0, \text{ otherwise } f(x) = 0, w \in R^n, t \in R\}$, and F_2 is the class of unions of two half-spaces

$F_2 = \{f: f(x) = 1 \text{ if } w_1 \bullet x - t_1 > 0 \text{ or } w_2 \bullet x - t_2 > 0, \text{ otherwise } f(x) = 0, w_1, w_2 \in R^n, t_1, t_2 \in R\}$. Baum pointed out that in the half-space case, under reasonable assumptions about D, the perceptron algorithm has been shown to learn very rapidly (Baum, 1989), and that with no assumptions on D, learning algorithms based on Karmarker's algorithm can also be proven to learn quickly (Blumer et al., 1987). The bad news is that for F_2 there are no comparable results, and it is not at all clear that an algorithm exists that can learn in polynomial time.

On a more optimistic note, Baum quoted the following result: Assume that examples are chosen from a distribution D on $R^n \times \{1,-1\}$, and assume that one attempts to load these examples on a feed-forward network having linear threshold units, W weights, and N units. If one can find a choice of weights such that at least $1-\varepsilon/2$ of the set of M random training examples are correctly loaded, then for M sufficiently large, one has high confidence that the network will correctly classify all but a fraction ε of future examples. More precisely, if $M \geq 32W/\varepsilon \ \ln(32N/\varepsilon)$ one has confidence at least $1-8e^{-1.5W}$ and for $M \geq 64W/\varepsilon \ \ln(64N/\varepsilon)$ one has confidence at least $1-8e^{-\varepsilon M/32}$.

Baum presented the following result on lower bounds: Any learning algorithm training a net with a single hidden layer will be fooled by some distribution if it uses less than about W/ε examples (Baum et al., 1989). He emphasized that both the upper and lower bound results depended

only upon the size of the network trained, and, in particular, that the complexity of the target function does not appear in these bounds. This was one more occasion to emphasize that these results depend upon the ability to load the examples. If the target function is too complex, the examples can not be loaded, and these results do not apply.

During the rest of the talk, Baum gave an interesting critique of these and similar results and of the theory of learning in which they are embedded. He noted that in practice the situation was much better than these bounds indicate--there is a large numerical gap between the the-oretical bounds and actual experience. Many practical examples get good generalization for $M \leq W$ (Denker et al., 1988). Other problems with practical implications include the wide disparity between the upper and lower bounds, the fact that the lower-bound result has been proved only for networks with one hidden layer, and the form of the lower-bound result, namely "if you use too few examples, there is a distribution that can fool you." Baum suggests that the disparity between practice and theory probably stems from the fact that, in practice, the distributions are trivial, the target function is trivial, or both. This and other arguments lead him to criticize the PAC learning model as being too restrictive, specifically be-cause a class is called learnable only if there is an algo-rithm that works for all distributions. He thus proposes a framework where the distribution is uniform, but where few restrictive assumptions are made about the target function.

This was the extent of the talk. However, for complete-ness I will briefly mention two other topics that are in the Proceedings paper. Baum describes some simple experi-ments and presents experimental results that are consis-tent with the rule $\varepsilon = W/M$, where is ε the error rate, W the number of weights in the trainee set, and M is the number of examples. He notes that for the experiments, generalization is worse for networks with two hidden layers, roughly by a factor of two. These simulations support the conjecture that the Vapnik-Chervonenkis dimension of a multilayer network is equal to the total number of weights.

The main result of the Proceedings paper is that the k-nearest neighbor algorithm learns a half-space rapidly. Suppose one has a set S of classified examples in Eucli-dean space. The k-nearest neighbor algorithm classifies a new example x by examining the k elements of S nearest to x in Euclidean distance. If more than half of these are positive, one guesses that x is positive, otherwise one guesses that x is a negative example. Baum proves the following theorem: For any $w \in S^n$, $0 < \varepsilon < 1$, $n \geq 2$, let $k = 36\ln(\varepsilon/4)$ (n/ε^2) and $M = \max(7k, 600\ln(\varepsilon/4))$. Call M examples from the uniform distribution on S^n, classify these as positive if $w \cdot x > 0$ and negative otherwise. Use these examples as a database for the k-nearest neighbor

algorithm. Then with probability $1-\varepsilon$, the classifier will correctly classify the next random example chosen uni-formly from S^n. Here,

$$S_n = \{x: x_1^2 + x_2^2 + ... + x_n^2 = 1\}.$$

Finally, Baum shows that when the target function is the union of two half-spaces, the number of examples needed for accurate classification is exponential in n. He concludes that the results are essentially negative in that the k-nearest neighbor algorithm will not be an effective algorithm for learning in high dimensions except in very special cases.

Complexity Theory of Neural Networks and Classifi-cation Problems, George Cybenko, Center for Super-computing Research and Development, University of Illinois, Urbana, Illinois. This is also a theoretical paper, which, as Cybenko says, is orthogonal to the work on learning exemplified by Baum's paper and the references given there. Cybenko deals with the complexity of repre-senting a function with a network and not with the com-plexity of learning that function. His long-term objective is to calculate estimates for of these complexity measures for important classes of engineering problems. Cyben-ko's complexity measure is in the same spirit--in the context of neural networks--as entropy is in the context of communication theory.

As in many good talks, the bulk of the time was devoted to describing the context and motivating the definitions. This involved a mathematical description of multilayered, feed-forward artificial neural networks, plus a descrip-tion of four applications of neural networks that are often cited in the literature as good examples of the capabilities of neural networks. The four examples are NETalk (Sejnowski et al., 1987), target classification from sonar data (Gorman et al., 1988), hand-written character rec-ognition (Burr, 1988), and spoken numerical recognition. In discussing these successful applications, Cybenko made the point that they only show there exists networks and training procedures (including termination criteria) that can give solutions to the underlying classification problems, and this is quite different from having a prov-ably successful methodology for determining network architecture and training rules for a specific application. He answers the question, Why do these work so well?, by interpreting the underlying problem as one of data inter-polation. In this setting, the following result by Cybenko makes it clear that neural networks with only one hidden layer can indeed interpolate a given data set.

Let I_n denote the n-dimensional unit cube, $[0,1]^n$, and let $C(I_n)$ denote the space of continuous real functions on I_n with the supremum norm. Denote by σ any continuous sigmoidal function, that is, σ is real and tends to $+1$ as x tends to $+\infty$ and to 0 as x tends to $-\infty$. Cybenko (Cyben-ko, 1989) has shown that sums of the form

$$G(x) = \sum_{j=1}^{N} \alpha_j \sigma (y_i \bullet x + \theta_j)$$

are dense in $C(I_n)$. This means that, given any set of data (x_i, f^i), $1 \le i \le n$, and any function $f \in I_n$ that interpolates this data, and given $\varepsilon > 0$, there exists a neural network with one hidden layer such that for all $x \in I_n$, the network returns a value $G(x)$ with

$$|G(x) - f(x)| < \varepsilon.$$

This is a comforting result for those looking for a mathematical answer to the above question. Also, it tends to demystify these examples. What this result does not say is how many nodes the network must have. This unanswered question, along with other observations and arguments, provides Cybenko's motivation for the need to introduce a definition of classification complexity that depends only upon the function to be classified.

Several definitions are necessary. The classification function g is assumed to be a real-valued, Borel measurable function defined on R^n. A class of discriminators S is a collection of Borel measurable sets. (Cybenko points out that S can be viewed as a class of concepts as used in learning theory. For example, in the talk by Baum, S was, in some instances, half-spaces and, in other discussions, unions of half-spaces.)

Let $S_m \subseteq S$ be a subset of S containing exactly m sets, and let $\sigma(S_m)$ be the σ-algebra generated by the sets in S_m. For a positive measure μ on the unit cube $I_n = [0,1]^n$, define

$$E(g, S_m, \mu) = \min \int_{I_n} |g(x) - f(x)| \, d\mu(x)$$

where the minimization is over functions f that are $\sigma(S_m)$ measurable.

Definition of Classification Complexity: The classification complexity of a function g with respect to a class of discriminators S, a measure μ, and a positive ε is

$$C(g, S, \mu, \varepsilon) = \min\{ m \mid E(g, S_m, \mu) \le \varepsilon \text{ for some } S_m \subset S \},$$

with the convention that $C(g, S, \mu, \varepsilon) = +\infty$ if such an m does not exist.

Cybenko presented several properties of this complexity function including the expected subadditivity. I will not spell these out but rather go directly to a central result that connects complexity to neural networks.

Theorem. Let S be the collection of all half spaces in R^n. Suppose that $C(g, S, \mu, \varepsilon) = m < +\infty$. Then there exists a feed-forward neural network with any sigmoidal

nonlinearity and m hidden nodes at the first layer such that if $N(x)$ denotes the output of the network for $x \in R^n$ then

$$\int_{I_n} |N(x) - g(x)| \, d\mu(x) < \varepsilon.$$

The complexity function introduced by Cybenko has the disadvantage, as he is quick to point out, that it is far from obvious how to apply it in practice. That may be so, but I believe that this line of investigation is going in the right direction. The subject needs the kinds of concepts and results exemplified by this work.

Contributed Papers on Theory and Algorithms

In this section, I will summarize ten contributed papers on theory and algorithms.

Generalization Performance of Overtrained Back-Propagation Networks, Yves Chauvin, Thompson-CSF, Inc./Pacific Rim Operations, Palo Alto, California. Chauvin presented simulation data on the performance of back-propagation for three tasks: (1) fitting the piecewise linear function

$$y = .8x + .2 \text{ for } -1 < x < 5$$
$$y = -.5x \qquad \text{for } .5 < x < 1$$

by training a 1-20-20-1 network on randomly chosen points from [-1,1]; (2) training a 1-20-1 network on 21 equidistant sample points in [-5,5] with $y = 1/(1+x^2)$; and (3) a speech-labeling task. In the first case, overtraining resulted in the development of overshoot at the discontinuity, which reminds one of a Gibbs phenomena. The second case was established to show behavior reminiscent of the Runga effect in approximation theory. The speech experiment showed two things: (1) the degradation of generalization performance with overtraining and (2) the amelioration of this by adding network reduction constraints to the back-propagation algorithm. Chauvin concludes that the adverse effects of overtraining result from too many *degrees of freedom* in the network, where *degrees of freedom* or *free parameters* are intuitive, undefined terms.

Stability of the Random Neural Network Model, Earl Gelenbe, École des Hautes Études en Informatique, Université René Descartes, Paris, France. In a previous paper (Gelenbe), Gelenbe introduced the concept of a random network. This is a network of neurons in which both positive and negative signals circulate. Each neuron accumulates signals in a counter. A positive signal advances the counter by 1, a negative signal reduces the counter by 1, but the counter never goes below zero. A

neuron holding a positive signal fires at random according to an exponential distribution with constant rate. When neuron i fires, it sends a positive signal to neuron j with probability $p^+(i,j)$, a negative signal with probability $p^-(i,j)$, and the signal departs the network with probability $d(i)$. Signals can also arrive from outside the network. Gelenbe showed in the cited paper that under certain conditions, the stationary probability distribution

$$p(k) = \lim_{t \to \infty} \text{Prob}[\, k(t) = k\,],$$

where $k(t)$ is the value of the vector of signal potentials at time t, and $k = (k_1,...,k_n)$ is a particular value of that vector, can be written as a product of marginal probabilities of the states of each neuron. This result follows by showing that a system of nonlinear equations involving the firing rates, transition probabilities, and arrival rates from outside has a unique solution. The current paper extends the results of (Gelenbe) by showing new conditions for classes of networks that imply the existence and uniqueness of this system of equations, and hence the product representation for the probability distribution. Gelenbe defines three classes of networks for which this holds: (1) feed-forward networks, (2) balanced networks, and (3) damped networks. These are defined in terms of conditions on the various probability distributions. Gelenbe also discussed an analogy between random neural networks and the more familiar connexionist neural networks.

Temporal Pattern Recognition Using Extended Back-propagation for Sequences (EBPS), Marco Gori, Giovanni Soda, Dipartimento di Sistemi e Informatica, Firenze, Italy. Gori has previously (Gori, 1989) introduced the idea of EBPS applied to a class of networks he calls Multilayered-like Networks (MLN-like). The MLN-like networks are composed of ordinary neurons and dynamic neurons. A dynamic neuron can use feedback from its own output, and also from its own output delayed, that is, at times t-1, t-2, ..., t-k. Gori presented the equations describing these networks, discussed the EBPS algorithm, and presented arguments for using MLN-like networks in temporal pattern recognition tasks. He also discussed the different roles of activation feedback and output feedback, where activation feedback involves using weighted sums of delayed activations in the current activation; that is, the activation potential $a_i(t)$ at time t contains terms of the form

$$w_{ii}k a_i(t-k)$$

involving the weights $w_{ii}k$ and activations $a_i(t-k)$ at previous times t-k. The paper included a description of an experiment on a network with 10 dynamic neurons in the hidden layer, 3 outputs, and 10 inputs. This experiment was designed to discriminate among three wave shapes--a square wave, a triangular wave, and a sine wave--independently of where the wave appeared in the sample frame; i.e., the discrimination was to be translation invariant. The training set was made up of tokens with 160 sample points. Each token had a wave signal on 40 points placed randomly within the token. Supervision took place only at the end of the tokens, and training and testing took place on 300 linked tokens. Gori reported that recognition improved with an increase in the number of delays, with k=4 giving perfect performance. The experiment was also done under a change of scale, that is, the wave forms were compressed. Finally, the network performed well under both translation and compression.

Markovian Spacial Properties of a Random Field Describing a Stochastic Neural Network: Sequential or Parallel Implementation? Thierry Hervé, Olivier François, Jaques Demongeot, Université J. Fourier de Grenoble, France. The authors have previously introduced a representation of neural activity in a random field (Hervé). This talk described the consequences of a result on the Markovian properties of this random field, specifically that the random field can model several kinds of dynamics. Thus, the random field provides both sequential and parallel simulations of a neural network. Arguments are given for using these models in connection with new data that is becoming available through optical methods for recording multi-neuronal activity. This all has to do with the question: Do real neural networks function in pure parallelism? The authors argue that their model, combined with new techniques in neurophysiology, provides the tools to discriminate between massive parallelism or semisequential behavior.

Chaos in Neural Networks, Steve Renals, Department of Physics and Centre for Speech Technology Research, Edinburgh University, Scotland. Chaos is everywhere. If it is good for your heart and brain, it is probably good for your artificial neural network. This is part of the motivation for the paper and talk, which extends previous work by Renals and Rohwer (Renals et al., 1990). Renals reported on the dynamic behavior of an N node network governed by the dynamic law (in its discrete form)

$$y_i(t + \Delta t) = (1 - \Delta t)y_i(t) + \Delta t f\left(r \sum_{j=1}^{N} w_{ij} y_j(t)\right),$$

where w_{ij} is an NxN weight matrix, r is the magnitude of the weight matrix, y_i is the output of node i, and

$$f(x) = (1 + \exp(-x))^{-1}.$$

Note that r is a gain factor in that it controls the slope of f. Another parameter, a, is introduced to vary the symmetry of the weight matrix: a = 1 corresponds to a symmetric matrix, a = -1 to an antisymmetric matrix, and a = 0 to a random matrix with uncorrelated elements. Renals presented the results of two kinds of simulations. In the first instance, he showed data for Δt = 1, 0.5, 0.25, and 0.125, where for each Δt, r took 13 values between 1 and 64, and a took 21 values between -1 and +1. The results show a full range of dynamic behavior. For r > 2.0 and Δt = 1, most networks were unstable exhibiting limit cycle or aperiodic behavior for all values of a. Smaller Δt and smaller gain produced more stable fixed point behavior. The other experiment set a = 0 and Δt = 1. Data were presented as the output of a single node as r was varied. Here one saw fixed point behavior for small values of r, bifurcation to oscillatory behavior at r = 5.28, complex (multi-periodic and aperiodic) behavior until r > 20, where a period 4 limit cycle attractor dominates, and so on. The interesting thing here is not that this happens--one expects this in a nonlinear system when the gain is raised--but that this 8-node system exhibits behavior typical for one-dimensional systems such as period doubling to chaos. Renals argued that this rich dynamic behavior may prove to be useful in engineering applications.

The "Moving Targets" Training Algorithm, Richard Rohwer, Centre for Speech Technology Research, Edinburgh University, Scotland. This algorithm is distinguished because it treats hidden nodes as target nodes with variable training data. "Moving Targets" means these targets are varied during training. Rohwer emphasized that the algorithm, outlined in the talk, applies to training the dynamic behavior of any discrete-time neural network. It can have any connectivity from feedforward to full feedback. The algorithm offers an alternative to backpropagation in the case of a feed-forward architecture. Rohwer presented computational results on several simple dynamical training problems. One impressive example had the network learn to fire a target node when--and only when--a second input pulse occurs, even though the first pulse was 100 time units in the past.

Acceleration Techniques for the Backpropagation Algorithm, Fernando M. Silva, Luis B. Almeida, Instituto de Engenharia de Sistemas e Computadores, Lisbon, Portugal. This algorithm is another attempt to speed up backpropagation. The idea is to adjust judiciously the learning rate for each individual node. Specifically, the equation for updating the weights is

$$w_{ij}(n) = w_{ij}(n\text{-}1) + \eta_{ij}(n)\nabla_{ij}E(n),$$

where $\nabla_{ij}E(n)$ is the ij-th component of the gradient of the quadratic error function E (w) at time n, and $\eta_{ij}(u)$ is the specific learning rate parameter of the ij-th node at time n. At each step, the learning rates are adjusted according to

$$\eta_{ij}(n) = \begin{cases} u\eta_{ij}(n-1) \text{ if } \nabla_{ij}E(n)\nabla_{ij}E(n-1) > 0 \\ d\eta_{ij}(n-1) \text{ if } \nabla_{ij}E(n)\nabla_{ij}E(n-1) < 0, \end{cases}$$

where u and d are positive constants with values slightly above and below unity, respectively. Silva presented the results of several experiments run in batch mode; that is, the weights were updated based on the sum of squares of differences taken over the total training set. In all cases, the algorithm performed better than simple backpropagation, and the performance was relatively insensitive to the initial values of the learning rates.

Rule-Injection Hints as a Means of Improving Network and Learning Time, S.C. Suddarth, ONERA/DES, Châtillon, France, and Y.L. Kergosien, Département de Mathématique, Université de Paris Sud, Orsay, France. Hints provide what appears to be a rather general technique to improve the performance of neural networks by both reducing training time and improving the probability of correct rule extraction. Suddarth discussed applications to backpropagation in feed-forward networks and to analog auto-associative memory, but it seems clear that the ideas have wider application. I will briefly discuss the backpropagation case.

Suppose one wishes to train a network on the set $\{x_i, y_i\}$, where the x_i are input vectors and the y_i the desired output vectors, say of dimension m. A hint is another set of data $\{x_i, z_i\}$, where the inputs are the same and where the output vectors z_i, say of dimension n, are "related" to the desired outputs y_i. The implicit assumption is that the network has at least m + n outputs. Training proceeds using the desired output plus the hint, thereby demanding more of the network than is ultimately required. One of Suddarth's examples is learning the XOR function on a 2-3-2 network. Input data (x,y,) are taken randomly from $\{-1,1\}x\{-1,1\}$, the XOR output is given by -xy and the hint used is (x-y)/2. Suddarth presented data showing the evolution of weights and errors during training in which the hint is added sometime after training had started. In this example, the weights were trapped at a local minimum at the origin until the hint was added. After the hint was added, the network sought a proper solution. In this example, the hint acts like a catalyst (Kergosien, 1985). Suddarth presented a geometric analysis and explanation of how the hint works in the XOR example. He also gave a general analysis of hints in terms of probabilities and an entropy function. Unfortunately, this analysis does not provide much guidance for choosing good hints; i.e., hints

that are somehow ideally related to the desired output. Suddarth ended by presenting results from several experiments showing that using hints improved learning time and performance.

Inversion in Time, Sebastian Thurn, Alexander Linden, Gesellschaft für Mathematik und Datenverarbeitung mbH, St. Augustin, Federal Republic of Germany (FRG). Inversion in the context of multilayer networks concerns the following situation and questions: Let N denote a network with n inputs and m outputs. Let S be the set of all possible inputs, and let T be the set of all possible outputs. Given an m-vector y, how does one determine if y is an element of T? Given y∈T, how does one determine the subset of n-vectors in S that produce y? Inversion is not a new topic (Williams, 1986 and Linden et al., 1989). The talk (and paper) extended inversion using backpropagation to recurrent, time-delayed, and discrete versions of continuous networks. This is done by first unfolding a recurrent network into an equivalent multilayer network. One then applies the inversion algorithm to the simple multilayer network. The next contribution was to describe an algorithm to answer the second of the questions posed above. Namely, given an m-vector y, is it a possible output of N? For this task, the authors have an algorithm they call inversion with validity intervals. The algorithm is too complicated to describe here; it suffices to note that the algorithm produces approximate intervals [a_i,b_i] that represent the interval of valid output for the unit i of the network. As well as I understood, the technique only tells one when an m-vector cannot be in T. Simulation results for three different tasks were presented: (1) the standard XOR, (2) Morse code detection, and (3) hand-written digit recognition. The result in the first case was there were no false inputs because the training set is complete. The next example was more complicated and interesting. Without going into detail, the simulation proved there was no input with false length that produced the outputs e, f, g, and h, where length refers to the number of Morse characters representing a letter. For example, the letter "g" has three characters, $--\cdot$, and thus length three. The hand-written digit recognition was even more complicated and interesting. The digits were coded by an (11 x 8)-pixel matrix; these were trained in 8 time steps with an 11-pixel window; the network consisted of 11 input, 20 hidden, 15 context, and 10 output units. After training by backpropagation, 82 percent of 140 further handwritten digits were classified correctly. However, backpropagation experiments asking the question: What inputs give the output "5"?, produced false inputs (spurious attractors), as did experiments for the other nine digits. In short, inversion can, and did, uncover spurious attractors.

Cellular Neural Networks: Dynamic Properties and Adaptive Learning Algorithm, Lieven Landenberghe, Shaohua Tan, Joos Vandewalle, Katholieke Universiteit Leuven, ESAT-Laboratory, Heverlee, Belgium. In 1988, L.O. Chua and L. Yang (Chua et al.) introduced cellular neural networks. They consist of a two-dimensional array of sparsely interconnected neurons, whose behavior is governed by the equation:

$$dx/dt = S(x - Dx - Fu - \theta) - x, \quad (1)$$

where x is the n-dimensional state vector for the n neurons, D is an nxn matrix (the *feed-back* matrix), u is an external input vector (say of dimension m, but usually of dimension n), F is an mxm matrix (the *feed-forward* matrix), θ is a constant, and S is the linear sigmoidal function applied component by component. Explicitly,

$$S_i(x) = 1 \text{ if } x_i \geq 1,$$
$$S_i(x) = x_i \text{ if } -1 \leq x_i \leq 1,$$
$$S_i(x) = -1 \text{ if } x_i \leq -1.$$

In the original paper, the authors assumed that D was symmetric, and they made no provision for learning; that is, the matrices were fixed based on an analogy with two-dimensional digital filters. The authors of the present paper use results from mathematical programing and circuit theory to derive properties of cellular neural networks under weaker assumptions on D, and they introduce an adaptive learning procedure. As a first result, they prove Theorem 1: Given Fu + θ, (1) has a unique equilibrium point if and only if D has positive principal minors. They next introduce the new variables and notation

$$Fu + \theta = c,$$
$$T = I - D,$$
$$w = S(Tx - c),$$
$$y = Tx,$$

and they write (1) as

$$dx/dt = -x + w, \quad (2)$$
$$y = Tx,$$
$$w = S(y - c).$$

Thus, (1) is written as a linear multivariable system with a decoupled nonlinear feedback, $w = S(y - c)$. The next result is Theorem 2: The cellular neural network for which D is nonsingular and T is positive converges from every initial state if the linear system in (2) is bounded real. In this case, the network has a unique equilibrium. Finally, the speaker presented an adaptive training rule

for the discrete version of (1) and results on edge detection using this system.

Improved Simulated Annealing, Boltzmann Machine, and Attributed Graph Matching, Lei Xu and Erkki Oja, Lappeenranta University of Technology, Lappeenranta, Finland. In the first part of this talk, Oja outlined the standard simulated annealing (SA) algorithm as background for discussing the improved simulated annealing (ISA) algorithm introduced by Xu (Xu, 1989). He discussed some of the shortcomings of SA and showed how the ISA improves the situation. Specifically, Oja argued that the solution obtained by ISA is always better the that obtained by SA, and that the computing cost is about the same. (I note that the ISA algorithm is not a complicated modification of the SA algorithm. However, it is a bit tedious to write out, and I refer you to the Proceedings for the details.) Oja then showed how to apply these ideas to the Boltzmann Machine, reaping similar benefits. Finally, he discussed the application of ISA and the Improved Boltzmann Machine to attributed graph matching, a problem motivated by work in computer vision and task assignment in distributed computing systems. Oja presented simulation data on attributed graph matching comparing SA with ISA and the Boltzmann Machine with the Improved Boltzmann Machine. In both cases, the improved versions of the algorithm produced better solutions at less time cost.

Contributed Papers on Speech Processing

Artificial Dendritic Learning, Tony Bell, Artificial Intelligence Laboratory, Vrije Universiteit Brussels, Belgium.

A Neural Net Model of Human Short-Term Memory, Gordon D.A. Brown, University College of North Wales, Bangor, U.K.

Large Vocabulary Speech Recognition Using Neural-Fuzzy and Concept Networks, Nobuo Hataoka, Hitachi Dublin Laboratory, Trinity College, Dublin, Ireland, and Akio Amano, Toshiyuki Aritsuka, Akira Ichikawa, Central Research Laboratory, Hitachi, Ltd., Tokyo, Japan.

Speech Feature Extraction Using Neural Networks, Mahesan Niranjan, Frank Fallside, Cambridge University Engineering Department, Cambridge, U.K.

Neural Network Based Continuous Speech Recognition by Combining Self Organizing Feature Maps and Hidden Markov Modeling, G. Rigoll, Fraunhofer Institute (IAO), Stuttgart, FRG.

Contributed Papers on Image Processing

Ultra-Small Implementation of a Neural Halftoning Technique, T. Bernard and B. Zavidovique,

ETCA/CREA/SP, Arcueil, France; P. Garda, and F. Devos, IEF, Université de Paris Sud, Orsay, France.

Application of Self-Organizing Networks to Signal Processing, Jonathan Kennedy, Pietro Morasso, Department of Computer Science, University of Genova, Genova, Italy.

A Study of Neural Network Applications to Signal Processing, Stefanos Kollias, Computer Science Division, National Technical University of Athens, Zografou, Greece.

Contributed Papers on Implementation

Simulation Machine and Integrated Implementation of Neural Networks: A Review of Methods, Problems, and Realizations, C. Jutten, A. Guérin, J. Hérault, Institut National Polytechnique de Grenoble, Grenoble, France.

VLSI Implementation of an Associative Memory Based on Distributed Storage of Information, Ulrich Rückert, Universität Dortmund, Dortmund, FRG.

Summary

Judging just by the number of recent conferences on neural networks in Europe, one might conclude that the connextionists are taking over. While I was at the meeting in Sesimbra, *The Third European Seminar on Neural Computing: The Marketplace* was held in London. The Lyon Conference, held every 2 years in selected domains of "Computer Science and Life," was devoted to neural networks this year; it attracted many of the superstars in the field. Other well-known researchers participated in the *International Conference on Parallel Processing in Neural Systems and Computers* held in Düsseldorf, March 19-21. The really big show, the *International Neural Network Conference*, was held July 9-13 in Paris. I mention these not as a calendar of events, but rather to put the Sesimbra meeting in context. The meeting was relatively small. On the other hand, the organizers enlisted the services of a large, illustrious technical committee to review the papers. I judge that the general quality of the papers was high. In fact, only 40 percent of the submitted papers were accepted.

As my reviews indicate, most talks were expositions or extensions of previously published work. The mixture of theory and experiment leaned toward the side of experiment, and at the risk of playing an old record, I was struck once again by the need for theoretical underpinning to guide engineering applications. The two invited papers were steps in this direction, but the authors are the first to lament the shortcomings of their results regarding practical applications. If the work presented at this meeting is representative, intuition and experience are still the most valuable tools for building a network to do a specific job. Yet, in spite of the trial-and-error nature of the

business, the activity represented at this and other recent European meetings shows that the neural network business is booming in Europe.

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The Ninth International Conference on Computing Methods in Applied Sciences and Engineering

by J.F. Blackburn

Introduction

The Ninth International Conference on Computing Methods in Applied Sciences and Engineering was held in Paris, January 29 - February 2, 1990. Of 160 participants, daily attendance averaged between 70 to 90. Attendees came from Western Europe, U.S., Algeria, Taiwan, Japan, U.S.S.R., and Canada. Many local registrants attended selectively during the course of the week.

The presentations concentrated mainly on applied science and engineering problems, emphasizing fluid dynamics. Also, there were several talks on supercomputer architecture. I provide summaries of presentations here.

Session 1, Computational Fluid Dynamics I

There were two sessions on fluid dynamics. This first session consisted of four presentations.

Hypersonic Flow Simulations Using Direct Simulation Monte Carlo Methods, J.N. Moss, NASA Langley Research Center, Hampton, Virginia

G.A. Bird's Direct Simulation Monte Carlo (DSMC) method was presented. This method can simulate real gas flows for vehicles at very high altitudes. Moss reported recent developments and applications of the methods for hypersonic flows were reported for ground-based tests and during vehicle entry. Moss also included

results obtained from axisymmetric and three-dimensional (3-D) codes.

At high altitudes, the rarefied flow regime (the molecular mean-free path in the gas) becomes significant when compared with either a characteristic distance over which important flow-property changes take place, or when compared with the size of the object creating the flow disturbance. Since the flow is hypersonic, the flow disturbance that envelopes the space vehicle will be a nonequilibrium flow. This means one in which nonequilibrium exists among the various energy modes, chemistry, and radiation for the more energetic flows. For such flows, the shock-wave thickness is significant, and the flowfield disturbance created by the vehicle is much larger than that experienced under continuum flow conditions. At the surface of the vehicle, the gas-surface interactions are very important because they significantly influence the aerodynamic forces and heating that the vehicle experiences. The discrete nature of the flow needs to be considered. Because of the limitations of the continuum description, by the Navier-Stokes equations, to simulate rarefied flows and the difficulties of solving the Boltzmann equation that acknowledges the discrete nature of the flow, direct physical simulation methods were developed for modeling rarefied effects. These developments have generally been concerned with the DSMC method and (to a lesser extent) with the Molecular Dynamics method. The DSMC method is the most used today for simulating rarefied flows in an engineering context. This method takes advantage of the discrete structure of the gas and provides a direct physical simulation instead of a numerical solution of a set of model equations. The solution is accomplished by developing phenomological models of the relevant physical events. Such models have been developed and implemented in the DSMC procedure to account for translational, thermal, chemical, and radiational, nonequilibrium effects. This paper reviewed the general features of the DSMC method, the numerical requirements for obtaining meaningful results, models used to simulate high-temperature gas effects, and applications of the method to calculate the flow about various configurations under hypersonic low-density conditions. Results obtained using both axisymmetric and 3-D codes were included.

The Computation of Compressible Fluid Flow on Unstructured Grids, K. Morgan et al., University of Wales, Swansea, U.K.

The governing equations used in computation are those for compressible viscous flow and viscous tensor analysis.

Strengths of using unstructured grids include:

- Ease of modeling complex geometries
- Incorporation of adaptive strategies
- Speed of process accomplishment.

Weaknesses of using unstructured grids include:

- Difficulty of quality control in mesh generation
- Lack of good adaptive procedures for viscous fluids
- Rather crude error estimates.

The Taylor-Galerkin method of solution is a time-stepping scheme based on finite-element discretization. The explicit procedure is conditionally stable.

There are two alternatives in using line relaxation--implicit and explicit algorithms. Unstructured line relaxation is used for the double ellipsoid in which the line runs through each point.

Upwind schemes are cell-centered and apply the Rieman Solver. This scheme allows for higher-order extensions.

On the Numerical Simulation of Chemically Reactive Flows, B. Larrouturou, Institut National de Recherche en Informatique et en Automatique (INRIA), France

A family of approximation methods were presented for the numerical simulation of a multidimensional flow of a reactive perfect or real gaseous mixture. All of these methods employ a second-order, accurate, upwind approximation using slope limiters giving an oscillation-free solution. In addition, the schemes operate on any finite-element mesh. Thus, these schemes generalize for multicomponent flows the finite-element, upwind methods developed for a single gas in the spirit of the Monotonic Upwind Schemes for Conservation Laws (MUSCL) methodology of B. Van Leer.

The methods improvements are related to the coupling of the mass fractions equations with the basic hydrodynamic equations. In particular, a family of methods was derived that have the property of preserving the maximum principle for the mass fractions of all species in the gaseous mixture.

This coupling between the mass fractions equations and the gas dynamics equations is considered through the study of a generalized Rieman problem for one-dimensional (1-D) multicomponent gas dynamics. These strategies have provided robust and accurate solutions of many reactive flows at various regimes. They range from highly sub- to hypersonic reactive flows, in simple or complex geometries, and in two- or three-space dimensions.

Three-Dimensional Compressible Reacting Flow Computations with Unstructured Meshes, B. Stoufflet, Avions Marcel Dassault-Breguet Aviation, Saint Cloud, France

The design of a new generation of space vehicles, such as the advanced space transportation system or the European space shuttle program, requires the development of efficient, numerical flow solvers considering adapted thermodynamical and chemical modeling. During the

re-entry into the atmosphere of such vehicles at high-velocity and at altitude, dissociation, ionization, and excitation of internal energy modes of air have to be considered. The gas is no longer a perfect gas and thermal and chemical nonequilibrium models must be included in the set of equations. When the characteristic times of these phenomena are small enough compared to the fluid motion characteristic time, all the processes are in equilibrium with their reverse processes. In this case, it is only necessary to replace the perfect gas law with a general gas law.

This paper covered an extension of an Euler flow solver using unstructured meshes to handle equilibrium and/or nonequilibrium reactive flow simulations. For perfect gas computations, the Osher Rieman solver was chosen as an upwind idea combined with an unstructured grid MUSCL-type approximation. This solver had proved to be robust and free of any tuning parameters. The plan is to keep these properties for real gas simulations by deriving an adapted generalization of this idea.

Recently, Larrouturou et al., have shown that, for a mixture of perfect gas components, the computation of Rieman invariants is possible and is a straightforward extension of the single, perfect gas situation. The constitution of the mixture and the ratio of specific heats are only changed in the contact discontinuity and remain constant along the first and third subpaths. Unfortunately, for a mixture of only thermally perfect gases, no simple analytic expression of Rieman invariants is available. Nevertheless, it seems reasonable to advocate using approximate Rieman solvers, and this approach has been investigated for chemical equilibrium flows.

The paper included a possible generalized Rieman solver for a mixture of thermally perfect gases with nonequilibrium chemical assumption. Then, a simple generalized Osher solver was proposed when chemical equilibrium is assumed. Numerical experiments were presented in two- and three-dimensions of hypersonic flow simulations on adapted nonstructured meshes. The experiments validated and illustrated the possibilities of the reactive flow solvers.

Session 2, Supercomputer Architectures

There were four presentations in this session. Two were from computer manufacturers, and two were from universities.

The Fujitsu VP 2000 Series Supercomputer Systems and Their New Applications, K. Miura, Fujitsu America Inc., San Jose, California

The FACOM VP 2000 series was announced in December 1988, with first delivery in March 1990. The VP 2000 system uses chilled water equipment for cooling. Miura announced that there are now 15 Fujitsu supercomputers in Europe, including one in France. The largest model--the VP 2600/20--consists of a dual scalar processor (clock period 5 ns) and one vector processor with a maximum performance of 5 Gflops. Also, the processor has 128 Kbytes of reconfigurable vector registers. Associated with these vector registers are 2 Kbytes of mask registers. The maximum main storage capacity is 2 Gbytes. The VP 2600/10 has only one scalar processor.

The VP 2400 has half the performance of the VP 2600--2.5 Gflops. The VP 2200 has a performance maximum of 1 Gflops, 32 Kbytes of vector registers, and 512 Kbytes of mask registers. The VP 2100 has the same amount of registers as the VP 2200 but only half the peak performance of the VP 2200. The smallest main storage available is 32 Mbytes. All systems can be delivered with or without a second scalar processor, referred to as model 20 or model 10. Each VP 2000 system has extended storage of 1-8 Gbytes and 16-128 channels with a maximum transfer rate of 1 Gbyte/s.

The central processor is built from high-density (15,000 gates/chip) emitter, coupled logic LSI chips with 80-picosecond gate delay and 64-Kbit RAM logic LSI chips with 1.5-nanosecond access time. The main storage consists of 1-Mbit static RAM chips and has an access time of 35 nanoseconds.

The NEC Supercomputer SX-3 Series Architecture and Software, A. Iwaya, NEC, Tokyo

In April 1989, NEC announced the SX-3 Series consisting of 7 model configurations, with maximum performance ranging from 1.37 Gflops for the processor Model 11, to 22 Gflops for the 4 processor Model 44. Iwaya announced that delivery of the SX-3 would begin in Japan in June 1990 and overseas in September 1990.

The SX-3 features are:

- Very powerful multiprocessor system with up to 4 arithmetic processors

- High-speed single processor performance of 5.5 Gflops peak which is achieved by a machine cycle time of 2.9 ns and 16 vector pipelines

- Leading edge technologies, such as very large-scale integration (VLSI), with 20,000 gates, and 70-picosecond switching time, and high-density, multi-chip packages

- Super-UX, a UNIX-based operating system with multiprocessors and multiprocessing functions

- Fortran 77/SX with auto-parallelizing and vectorizing functioning, and various tuning and debugging support tools.

Large-Scale Applications of Transputers: Achievement and Perspective, D.J. Wallace, Edinburgh University, U.K.

The Edinburgh Concurrent Supercomputer (ECS) Project is built around a Meiko Computing Surface, that

now has 400 floating point transputers and 1.7 Gbytes of memory. In 1980, work at Edinburgh University (Edinburgh) using parallel computers for physics applications began in 1980 on the International Computers Limited (ICL) Distributed Array Processor (DAP) at Queen Mary College. Through funds from the Science and Engineering Research Council (SERC), Edinburgh received its own DAP in 1982. In April 1986, with the support of the Department of Trade and Industry, and the Computer Board, Edinburgh obtained a Meiko Computing Surface demonstrator system of 40 T414 transputers, each with 1/4 Mbyte, along with a display system, and is file served and networked through a micro-VAX host.

Phase I funds for the machine infrastructure and computer resource of 200 T800 transputers, each with 4 Mbytes of memory, were secured during 1987. Multiuser service for code development was established in September 1987 and the first T800 system was installed at the end of 1987.

For well-structured Fortran or C code, which is floating point intensive, benchmarks for single precision give up to 0.6 or 0.7 Mflops per node (T800). Several applications written in occam are running in excess of 1 Mflops per node.

Currently, there are over 300 registered users of the facility. The applications fall under the three broad headings of: visualizing and image processing, simulation and control, and interaction design.

Examples of visualizing and image processing:

● Radiosity which can produce 3-D visualization of very high quality. The method is based on: (1) dividing the surfaces in the scene into N patches and determining line of sight visibility between pairs of patches; (2) solving the N simultaneous equations for the brightness of each patch; (3) and rendering the scene using z-buffering or ray-casting.

● An undergraduate project in computer science was undertaken to construct fractal planets. The C code ran 20 times faster on the ECS than on a SUN 3/60. Also, the level of natural parallelism in the ray-casting phase enabled the largest domain available on the ECS (130 T800s) to be used efficiently. The most complicated picture took 1 hour on the domain.

Applications in simulation and control include applying lattice field theory in High-Energy Physics, work in high-temperature superconductors, neural network modeling, and chemical process simulation and control.

In interactive design, an application concerns optimizing cutting patterns for tension structures such as the Schlumberger Headquarters in Cambridge.

Compiler Optimization for Superscalar Computers, M. Lam, Stanford University, California

Through executing multiple scalar operations per cycle, a superscalar architecture can parallelize not just vectorizable programs, but also code containing recurrences and data-dependent control flow. The paper comprised an overview of the compiler optimizations that are crucial in harnessing the computation power of a superscalar machine. These optimizations include high-level loop transformations to find parallelisms and improve the efficiency of caches, software pipelining, and hierarchical reduction techniques for scheduling instructions, and modulo variable expansion for assigning registers.

Recent advances in hardware technology have made superscalar architectures amenable to single-chip implementations. The combination of cheap hardware can produce extremely low-cost, high-performance workstations that are easily accessible to the general scientific and engineering community. The combination also provides a high, raw computing power and sophisticated compiler technology to effectively use the parallelism.

Session 3, Advances in Software

Four speakers in this session covered parallel multiprograming software, parallel execution of Fortran programs, sparse matrix computations, and parallelism on the Cray system for multitasking.

New Research Directions for Parallel/Multiprograming Software and the Cedar Project, C.D. Polychronopoulos, University of Illinois, Urbana

Parallel computer architectures and hardware have evolved impressively in the last few years from the architecture and the hardware viewpoint. However, progress in software development can only be classed as moderate. The lack of widely accepted methods and software to support parallel programing is profoundly evident even on the most advanced parallel machines. The performance of a parallel program can be influenced by many different factors such as coding of parallel constructs and/or restructuring, scheduling schemes and overhead, synchronization and/or communication cost, program and data partitioning, and memory allocation. This paper covered the major aspects of parallel programing. Parallel programing environments were considered in the three phases: parallelism specification and exploitation, and supportive environments and tools. A parallel programing environment built at the University of Illinois was discussed as a case study. Finally, the influence of parallel programing on multiprocessor operating systems was discussed, together with future directions.

Parallel Execution of Fortran Programs on the Euro-Work Station, F. Thomasset et al., INRIA, France

EuroWork Station (EWS) is an European Strategic Programme for Research Development in Information Technologies (ESPRIT II) project to create a high-performance technical workstation. The INRIA group's goal is to design and implement tools for transforming sequential Fortran applications into parallel Fortran applications and allow them to run on a multi-SPARC workstation.

The EWS project's intent is to realize a parallelizer and a parallel Fortran compiler. The parallelizer will analyze the DO loops of a Fortran program to detect parallelism independently of the machine's architecture. The parallelizer's output will be a Fortran program in which sequential and parallel regions are distinguished and synchronization barriers are minimized. The company Bull is in charge of realizing of the interaction parallelizer. The compiler uses the parallelizer's results to implement parallel execution on a multi-SPARC architecture. This project's work is cooperative effort with the ESPRIT project Generation of Interactive Programing Environments.

Sparse Matrix Computations on Supercomputers, H.A.G. Wijshoff, University of Illinois

This paper covered some of the key issues for implementing efficient, sparse computational codes on supercomputers. Computations on dense matrices may run near the peak performance of new architectures, but for computations on sparse matrices this is not true. Sparse matrix computations are characterized by the relatively few computations per data element and the irregularity of the computation. Both of these facts may significantly increase the overhead time because of memory references. Further, developing the code for handling sparse matrix computations is far from trivial. Using sophisticated data structures, together with complex control flow, make designing codes for sparse matrix computations difficult.

There are essentially three different techniques for generating parallelism in direct solvers for general linear systems of equations. The first technique exploits parallelism at the level of the rank-1 update. Second, multiple rank-1 updates can be performed in parallel. This mainly requires a search for a set of diagonal or triagonal pivots. Third, a global ordering can be used to decompose the sparse matrix into blocks which can be factored in parallel.

Another technique is based on identifying subsystems that are sufficiently small and have a reasonable amount of fillin. These subsystems can be treated as dense matrices and dense factorizations that can be used which are generally more efficient than sparse factorizations.

The techniques used in a direct solver--McSparse--included obtaining a sparse code that would exploit different levels of parallelism. The Cedar architecture, developed by D. Kuck et al., was mainly used in developing the first version of McSparse. Now, the code is being ported onto a Cray 2 and a Cray YMP.

Parallelism on Cray Multiprocessor Systems: Concepts of Multitasking, W.E. Nagel, Zentralinstitut fur Angewandte Mathematik Forschungszentrum (K.F.A.), Julich, Federal Republic of Germany (FRG)

Modern supercomputers like Cray X-MP and Cray Y-MP achieve their high computing speed by using both vector and parallel hardware. This paper included a short introduction to the Cray Y-MP system architecture and described the multitasking concepts that can be used on this machine. There are three different concepts that support parallelism on the programing language level--macrotasking, microtasking, and autotasking. Macrotasking supports coarse-grained parallelism on the level of subroutines. With microtasking, fine grain parallelism can be used even on the level of the DO loops. In contrast to these concepts where the multitasking primitives must be introduced by hand, the new autotasking concept offers an automatic way for finding parallelism in existing Fortran programs. These concepts and implementations were discussed, and measurements of the overhead and performance results for kernels and an application program were presented.

The overall system is of interest when multitasking concepts are used. Therefore, a programing system was developed, generating synthetic user programs that simulate a given workload in a flexible way. The resulting benchmark environment was used to insert additional sequential as well as parallel programs. This technique guarantees constant system load and enables reasonable comparisons. First results from these comparisons proved the efficiency especially for the fine-grain concepts that provide good performance in dedicated as well as batch oriented multiprograming environments. For selected production codes on the Cray Y-MP, these concepts are now used to evaluate their effects on a loaded system.

Session 4, Numerical Models

The Numerical Models session covered vortex flows via multigrid continuation, computational fluid dynamics, multilevel Wavelet-Galerkin methods for partial differential equations, and domain decomposition methods for certain problems.

Wavy-Taylor-Vortex Flows via Multigrid Continuation, H.B. Keller and W. Schroeder, Caltech, Pasadena, California

The calculation of wavy-Taylor-vortices in the flow of a viscous fluid between rotating concentric cylinders has

been achieved using multigrid continuation methods. These flows bifurcate from the (toroidal) Taylor-vortices, and they are steady travelling wave solutions of the full 3-D Navier-Stokes equations. The first wavy-vortex solution was obtained by using time-dependent equations and switching between a rotating and a fixed coordinate system to find the correct wave speed. Having found one such solution, continuation proceeds easily. The unsteady calculations are extremely computationally intensive since they are four-dimensional (4-D). However, the authors were able to get accurate results agreeing with experiments and other calculations using multigrid methods on a SUN 3/280.

New Developments in Adaptive Methods for Computational Fluid Dynamics, J.T. Oden and J.M. Bass, University of Texas, Austin

In computational fluid dynamics (CFD), conventional methods of flow simulation are gradually being displaced or augmented by adaptive schemes. These methods automatically modify themselves during the course of a calculation to accommodate changing properties of the numerical solution. Adaptive methods are designed to optimize and control the computational process. They should produce the best results, in some sense, for the least computational effort, and to control the quality and stability of the evolving solution. The control parameters are the accuracy of the solution, as measured by the error in some appropriate norm. The stability or robustness of the method is determined by the time step, the number of iterations, the artificial viscosity, or similar parameter. Therefore, successful adaptive methods must embody a technique for a posteriori error estimation and control. Once an estimate of the control variables are in hand, the control is imposed by changing the structure of the numerical method, and typically, this is accomplished by one or more of the following approaches:

- h-methods-local mesh size is changed by refining or regenerating the mesh
- p-methods-the local spectral order of the approximation is changed
- r-method-grid points are relocated to increase or decrease mesh density.

The control of these parameters and the time-step delta t is accomplished using smart algorithms that are designed to function on unstructured meshes, and to adjust themselves to changing accuracy and stability requirements.

The authors described several new developments in adaptive methods for CFD problems. Some of these

methods have been incorporated into a production CFD code, ADAPT, that uses h-method ideas to treat broad classes of flow problems, and in a companion code, PHASER, that is based on a new combined h-p method to resolve broad classes of boundary and initial value problems. Extensions of the h-p strategies to compressible and incompressible flows were described, together with a new technique for adaptively controlling the local implicit or explicit form of a CFD algorithm.

The authors also discussed applications to rotor-stator interaction, rotorcraft aerodynamics, shock and viscous boundary layer interaction, and fluid-structure interaction problems.

Multilevel Wavelet-Galerkin Methods for Partial Differential Equations, W. Lawton et al., AWARE, Boston

In this paper, the authors described selected developments in wavelet-based numerical methods for solving partial differential equations. The paper was limited to a small, but representative set of equations in one space variable. In particular, the paper covered the Daubechies wavelet solution of boundary value problems and initial boundary value problems for ordinary and partial differential equations in one-space dimension. The theoretical and numerical results suggest that, for the above class of problems, wavelets provide a robust and accurate alternative to more traditional methods such as finite differences and finite elements. The 1-D analysis carried out in this paper can also be seen as a necessary step to the solution of multidimensional problems where various technical issues remain unresolved. Methods for solving such problems are now being developed.

Domain Decomposition Methods for Unsteady Convection-Diffusion Problems, Yu. A. Kuznetsov, Academy of Sciences, Moscow

This paper dealt with systems of linear algebraic equations arising in application of the finite element method to elliptic boundary value problems with singularly perturbed operators. These problems appear in the use of implicit difference methods for solving parabolic equations including unsteady convection-diffusion problems. To solve finite element method systems, the author suggests both iterative methods with multilevel domain decomposition preconditioners, and noniterative domain decomposition methods with overlapping subdomains. The latter methods exploit the property of fast exponential decay of grid Green's functions of singularly perturbed elliptic operators. Also, the authors discussed justification and practical implementation of the domain decomposition methods.

Session 5, Computational Physics and Chemistry I

In this fifth session, computational physics and chemistry discussion covered quantum mechanical dynamics of chemical reactions and software environments for solving partial differential equations in parallel.

Quantum Mechanical Dynamics of Chemical Reactions, D.G. Truhlar, University of Minnesota, Minneapolis

This paper reviewed the Generalized Newton Variational Principle for 3-D quantum mechanical reactive scattering. Three techniques that improve the efficiency of the computations were described. Use was made of the fact that the Hamiltonian is Hermitian to reduce the number of integrals computed, and then the properties of localized basis functions were exploited to eliminate redundant work in the integral evaluation. In addition, Truhlar suggested a new type of localized basis function that has desirable properties. Finally, the author demonstrated how partitioned matrices can be used with localized basis functions to reduce the amount of work required to handle the complex boundary conditions. These new techniques do not introduce any approximations into the calculations. Thus, the calculations may be used to obtain converged solutions of the Schrodinger equation.

Software Environments for the Parallel Solution of Partial Differential Equations, R. Scott, University of Texas, Houston

Programing difficulty is a major obstacle to achieving the overall performance of today's multiprocessor supercomputers or the cost-effectiveness of the newer "parallel VLSI supercomputers." Performance gains are being achieved by the developing complex algorithms such as multi-grid; however, such algorithms are often avoided even on conventional architectures because of the difficulty of programing them. The author and his colleagues are developing techniques for implementing highly efficient algorithms for scientific computation on parallel architectures by combining expertise in computer science and mathematics. The objective is to do so in a way that the resulting codes are both efficient on, and portable among, a wide range of parallel computer architectures.

In the past, most research on parallel programing languages has been devoted to programing multiple tasks on a single processor, as must be done in an operating system for a conventional computer. However, new performance gains are now expected from parallel computers that cooperate on a single task. Programing language techniques for the latter environment are being studied by many researchers. The author proposed a language construct that allows code on one processor or process to access variables explicitly (by name only) that are stored in another processor or process. Thus, it permits programing a distributed memory machine as if it has a common address or name space. This technique led to significantly shorter development time for parallel codes as well as improved portability and reliability. Many diverse algorithms can be programed quickly to obtain excellent performance. The technique is being extended to include using advanced programing languages that allow the implementation of abstract data types. This makes coding and debugging finite element and finite difference applications more quickly and reliably.

Session 6, Supercomputer Applications

This session included techniques for large-scale incompressible flow computations, parallel ray-tracing algorithms, domain decomposition methods, and data management.

Solution Techniques for Large-Scale Incompressible Flow Computations, T.E. Tezduyar, University of Minnesota, Minneapolis

A comparative investigation was presented, based on a series of numerical tests, of various velocity-pressure elements used for incompressible flow computations. These elements were implemented in conjunction with the one-step and multi-step temporal integration of unsteady Navier-Stokes equations. The group of elements studied included the element with a Petrov-Galerkin stabilization that allows equal order (bilinear) interpolation functions for velocity and pressure. The test cases chosen were the standing vortex problem, the lid-driven cavity flow, and flow past a circular cylinder.

Improving a Parallel Ray-Tracing Algorithm on an iPSC/2 by Emulating a Read Only Shared Memory, D. Badouel and T. Priol, INRIA, France

Producing a realistic computer-generated image requires a large amount of computation and a large memory capacity. This process can be performed faster using highly parallel machines. Distributed memory-parallel computers, like hypercubes or transputer-based machines, offer an interesting cost/performance ratio, assuming that a load balancing and a partition of the data domain is found. This paper dealt with the demonstration that emulating a shared memory on these computers seems to be the best way to parallelize algorithms (like ray-tracing) that use large read-only databases with no obvious distribution. Results were given that permit comparison with a previous parallel ray-tracing algorithm implemented on an iPSC/2.

Domain Decomposition Methods with Non-Overlapping Subregions and Parallel Computing, F.X. Roux, Office National d'Etudes et de Recherches Aerospatiales, France

Two classical domain decomposition methods with nonoverlapping subdomains were presented: a conform-

ing domain, the Schur complement method; and a non-conforming domain, based on a Lagrange multiplier to enforce the continuity requirement at the subdomain interface. These methods represent dual formulations of a condensed problem on the interface. The parallel implementation problem of these methods was addressed. In like manner, the results of some numerical experiments for ill-conditioned 3-D structural analysis problems were given.

The Schur complement and the hybrid-domain decomposition methods appear, in practice, to have mixed characteristics of direct and iterative solution methods. They are iterative methods because they consist in solving an interface problem through the preconditioned conjugate gradient method. Like other iterative methods, they require less memory than direct methods because only the lower-triangular/upper-triangular (LU) factorization of small local matrices are to be stored.

With domain decomposition methods, the dimensions of the problem to be solved through an iterative method is much smaller than the dimensions of the complete problem. Also, the matrix of the condensed problem on the interface is much more dense than the usually sparse matrix of the complete problem. Further, its condition number is lower because the elimination of the variables associated with the internal nodes represents some kind of block Jacobi preconditioner.

When using direct local solvers, these characteristics make these domain decomposition methods much more robust than standard iterative methods. They represent a good way to use direct solvers for problems with such large numbers of degrees of freedom that the solution of the complete problem through an LU factorization would not be affordable.

The authors described tests that show that domain decomposition methods can (with a well-suited splitting of the domain) be less expensive than direct solvers in computer time and memory requirements. This is true even for very ill-conditioned 3-D structural analysis problems. These methods lead to a very high degree of parallelism. Furthermore, they are very well suited for implementation on parallel systems with local memories, such as distributed memory or hierarchical memory machines.

Data Management for 3-D ADI Algorithm on Hypercube Application to the Design of a Parallel Navier-Stokes Solver, P. Leca and L. Mane, ONERA, France

This paper dealt with the adaptation to hypercube multiprocessors of a 3-D Navier-Stokes solver based on an alternating direction implementation (ADI) algorithm. Two solutions for the management of data transfer through the communication network were discussed. Performance results of the implementation on a 32-node iPSC/2 were presented.

Session 7, Numerical Methods

This session dealt with Krylov subspace methods, Newton's methods, the Lancelot Project, and adaptive polynomial preconditioning techniques.

Rayleigh Quotient Iteration as Newton's Method, R. Tapia, Rice University, Houston, Texas

The inverse, shifted inverse, and Rayleigh quotient iterations are algorithms for computing an eigenpair of a symmetric matrix. In this talk, the authors showed that each one of these three algorithms can be viewed as a standard form of Newton's method from the constrained optimization literature. This equivalence leads naturally to a new proof of the cubic convergence of Rayleigh Quotient Iteration.

Krylov Subspace Methods: Theory, Algorithms, and Applications, Y. Saad, NASA, Ames Research Center, Moffett Field, California

This paper gave an overview of projection methods based on Krylov subspaces for solving various types of scientific problems. When applied to a linear system $Ax = b$, the main idea of this method's class is to generate in some manner an approximate solution to the original problem from the so-called Krylov subspace Span (b, Ab,... A^{m-1} b). Thus, the original problem of size N is approximated by one of dimension m, typically much smaller than N. Krylov subspace methods have been very successful in solving linear systems and eigenvalue problems. The authors showed some of the main ideas in Krylov subspace methods and discussed their use in solving linear systems, eigenvalue problems, parabolic partial differential equations, Lyapunov matrix equations, and nonlinear systems of equations. Some numerical experiments were presented to illustrate the concepts.

An Introduction to the Structure of Large Scale Nonlinear Optimization Problems and the LANCELOT Project, Ph.L. Toint et al., Institut Universitaire Notre Dame de la Paix, Namur, France

This paper gave the authors' views on two fundamental aspects among recent developments in the field of large-scale nonlinear mathematical programing. Important concepts for the description of a problem structure were discussed, and a systematic approach to software development for this class of problems was presented. The approach incorporates suitable numerical algorithms and user-oriented standard format for problem specification in a modular and coherent system.

The term LANCELOT in the software project stands for Large and Nonlinear Constrained Extended Lagrangian Optimization Techniques. The objective of this software project is to attack large problems involving nonlinear objectives and/or constraints by using techniques based on the Lagrangian function.

Adaptive Polynomial Preconditioning for Hermitian Positive Definite (HPD) Linear Systems, S.F. Ashby et al., Lawrence Livermore National Laboratory, California

This paper explored the use of adaptive polynomial preconditioning for HPD systems, $Ax = b$. Such preconditioners are easy to employ and well-suited to vector and/or parallel machines. After exploring the role of polynomial preconditioning in conjugate gradient methods, the authors discussed the least squares and Chebyshev preconditioning polynomials. Those eigenvalue distributions for which each is well suited were determined. Also, the authors described an adaptive procedure for dynamically computing the optimum Chebyshev polynomial preconditioner. Finally, in a variety of numerical experiments on a Cray X-MP/48 and an Alliant FX/8, the effectiveness of adaptive polynomial preconditioning was demonstrated. The results suggest that relatively low degree (2-16) polynomials are usually best.

Session 8, Computational Physics and Chemistry II

This second session on computational chemistry covered particle simulation of classical and quantum electron transport in semiconductors, simulation of rarefied gas flows, fast particle simulation, and the periodic Boltzmann semiconductor equation.

Computational Aspects of "Fast" Particle Simulations, C.R. Anderson, University of California Los Angeles

In many particle simulations, the calculation of the potential (velocity field, force) requires $O(N^2)$ operations where N is the number of particles. The author described the basic idea behind three methods that are employed to reduce this operation count to approximately $O(N)$. He discussed the issue of parameter selection for these methods and presented some computational evidence which demonstrated the importance of making good choices for the method parameters.

The author said that these methods by no means exhaust the set of possible methods, but they form a representative sample. For a starting effort, the direct method has the advantage of programing ease and computation accuracy. For a faster method, the next choice is between a grid-based method and a multipole-based method. For two-dimensions, there is no apparent reason to choose one over the other. However, for three-dimensions the choice depends on particle distribution. If the particles are not uniformly distributed, there may be good reason to select the multipole method.

Particle Simulation of Classical and Quantum Electron Transport in Semiconductors, P. Degond, École Polytechnique, Palaiseau, France

In this paper, a new numerical method was presented for the simulation of the Boltzmann Transport Equation

of semiconductors--the weighted particle method. The author described the kinetic model of the Boltzmann Equation and discussed the proposed solution method. Two different cases were discussed: homogeneous and nonhomogeneous, in which a coupled Boltzmann-Poisson system must be solved. The numerical study of the latter case was discussed.

The method was based on a deterministic treatment of the collision operator which may provide an accurate description of the physics of electron transport. The method was satisfactory in the homogeneous model and provided useful information for more macroscopic models. In the nonhomogeneous case, the comparisons show that the method is reliable and will give an accurate picture of the physical phenomena occurring in submicron structures.

Numerical Simulation of Rarefied Gas Flows, H. Babovsky, Universitat Kaiserslautern, FRG

This talk dealt with the progress of the Arbeitsgruppe Technomathematik in developing a simulation code for rarefied gas flows and in performing two-dimensional (2-D) and 3-D calculations for realistic situations. The work was done as part of a research and development program for the European space shuttle, HERMES.

The work is mainly concerned with 2-D and 3-D flows around bodies of different shapes. For example, they have performed 2-D calculations around double ellipses and 3-D calculations around flat disks with different angles of attack at a speed Mach 15.6 and around a delta wing with Knudsen numbers down to 0.01.

They used a rectangular grid structure for the calculations with an adaptive grid refinement. This cell system was efficient and reduced the computational effort materially. The complete code is about five times as fast as other simulation methods.

The Periodic Boltzmann Semiconductor Equation, P. Le Tallec et al., University of Paris, France

This paper dealt with the numerical solution of the Boltzmann semiconductor equation, in the case of a problem homogeneous in space. The main objective is the development of the fast deterministic solution procedure for the numerical computation of the steady-state solutions of the problem.

In this framework, the discretization strategy is based on an upwind finite difference approximation of the gradient terms and on a deterministic conservative calculation of the integral operators. The resulting algebraic system is then solved by a least squares method which reduces the system to a quadratic minimization problem to be solved by a standard conjugate gradient algorithm.

In the axisymmetric steady case problem with periodic boundary conditions, which models superlattices, this method gives good results for all values of the electric fields. These results are confirmed by an unsteady anal-

ysis which, although more expensive numerically, gives additional information on the relaxation behavior of the distribution function towards its steady state.

Session 9, Computational Fluid Dynamics II

This final session covered compressible flow algorithms, implicit centered methods for inviscid and viscous hypersonic flows, simulation of transition to turbulence in free-shear layers, and far field boundary conditions.

Compressible Flow Algorithms on Structured/Unstructured Grids, R.W. Walters, Virginia Polytechnic Institute, Blacksburg, Virginia

Walters discussed various techniques for implementing upwind flux-split schemes for the Euler and Navier-Stokes equations on unstructured meshes. The development of a space marching technique on hybrid structured/unstructured meshes was presented. Also, time integration algorithms were compared on unstructured grids with an emphasizing convergence acceleration to the steady state. An m-stage Jameson style explicit Runge-Kutta was used as a baseline comparison. Implicit methods discussed included a highly vectorizable skyline sparse matrix solver, hybrid explicit/implicit time advancement schemes, and various relaxation strategies. Mesh adaptation methods were also discussed. Results in both 2-D and 3-D were presented, including a supersonic inlet calculation with complex wave interactions and a space marching, inviscid simulation on an unstructured mesh about a high-speed reconnaissance aircraft.

Rapid and robust 3-D grid generation appears to be a primary topic requiring further attention, although a few research groups have demonstrated impressive results. In general, the CFD community does not appear to have this technology well in hand; however, significant resources are now being put into this effort. The flow solvers for unstructured meshes are progressing rapidly and do not appear to be hindering the transfer of technology to the user community.

Implicit Centered Methods Inviscid and Viscous Hypersonic Flows, A. Lerat, Institute National de la Santé et de la Reschersche Medicale (INSAM), Paris, France.

This paper demonstrated that the use of space-centered approximations can provide an accurate and efficient way to compute compressible flows with shocks, even at large Mach and Reynolds numbers.

The author presented the basic centered method used for solving the Euler equations. The method is a two time-level, implicit, finite-volume method that is conservative, second order accurate, and always linearly stable in any number of space dimensions. When applied to transonic aerodynamics, it gives nonoscillatory solutions with sharp shock profiles.

The author then described two modifications of this Euler solver that have been recently investigated for the calculation of hypersonic flows. The first one is the addition of a local entropy correction which preserves second-order accuracy and unconditional stability. This correction enforces a discrete entropy inequality at steady state. The second modification of the basic Euler solver concerns the introduction of a third-time level to improve the robustness of the method without altering the approximation at steady state.

Finally, the extension to the Navier-Stokes equations was discussed with particular attention to stability and convergence rate questions. Numerical applications to hypersonic problems were presented for inviscid and high Reynolds number laminar flows.

Far Field Boundary Conditions for Problems in Fluid Dynamics, B. Gustafsson, Uppsala University, Sweden

When solving flow problems in unbounded domains, it is necessary to introduce artificial boundaries. If the flow is smooth in the far field and there are no significant viscous effects, it is rather well known how to construct boundary conditions such that accurate solutions are obtained. However, sometimes the computational domain cannot be extended far enough. For example, when computing the flow around a solid body, the boundary may intersect the wall, thereby cutting through the boundary layer. In that layer, the gradients are very large for large Reynolds numbers, and the usual linearized equations are no longer valid.

The author analyzed a few model problems to get an understanding of the behavior of the solutions, depending on the boundary conditions. In particular, he discussed the procedure for using the inviscid conditions as the basic set, and then added viscous conditions of derivative type. In general, the errors introduced in this way are small provided the given data at the boundaries are accurate. If such data is not available, a common procedure is to extrapolate all variables. The author showed that this, in general, will introduce large errors. However, in the case with a boundary layer, the situation is more favorable. He then showed that large gradients along the boundary actually helps to keep the error minimal. Finally, he presented several numerical experiments which confirmed the theoretical results.

Parallel Processing in Control -
The Transputer and Other Architectures

by J.F. Blackburn

Introduction

This colloquium was sponsored by the U.K.'s Institution of Electrical Engineers and was held at their headquarters, Savoy Place, London. The meeting was attended by about 50 participants, most coming from the U.K. Nine papers were presented covering:

- Real-time control of high-speed machines using parallel processing methods
- Multimanipulator robot control
- Parallel methods in large-scale simulation
- Transputer usage in aircraft simulation and control
- Power systems control
- Woven mesh measuring and producing control.

Presentations

Following are summaries of the nine presentations.

Flexible Real-Time Control of Independently Driven, High-Speed Machines Using Parallel Processing Methods, D.J. Holden and G.F. Carpenter, Aston University

This paper described research into the specification, design, and implementation of real-time synchronization and control software for: a transputer controlled, modular, multi-axis, independently driven, high-speed packaging machine under normal and abnormal conditions. The research demonstrated the feasibility of using independent drives and software-based controllers to synchronize both intermittent and continuous motions. These applications are at the boundary of existing technology.

Complex high-speed machines, such as packing machines, have traditionally been designed around a prime mover that drives multiple, mechanically coupled, cam-actuated mechanisms to process and move materials and products. The desire for flexibility led to a requirement for machines that can rapidly produce a high volume of product in a short production run and can be reconfigured quickly to accommodate product change. Flexible control of such machines can be achieved by replacing the traditional centralized prime mover and associated mechanical linkages with a set of independent software-controlled drives that deliver power directly to the point of use.

The software that determines the actuators' functions and that coordinates and synchronizes the interactive motions of the actuator must be specified properly, designed correctly, and implemented accurately. This has involved work on modeling and verifying the specifications that define the safety and functional requirements, modeling and simulating the controlled axis motions and interactions. The work also includes using semiformal methods in designing and implementing the real-time control software.

The above method has been applied to a design of a control system for a two-axis demonstration rig comprising an incremental arbor drum and an intermittent transfer slider. The design method can be used to drive the synchronizing and controlling software for the multiple independent drives. The rig was successfully controlled using a variety of microprocessor and transputer-based systems.

The work demonstrated using transputers and Occam (programing language) in implementing prototype systems. The lessons learned during the demonstrator project are now being applied in industry, particularly during the design of new machines that can exploit the design freedom provided by using independent drives, or that exploits the ability to rapidly reconfigure a machine that incorporates software-controlled independent drives.

Transputer Hardware and Software for a Multimanipulator Robotic Environment, G. Dodds, The Queens University, Belfast

Cooperation between two robots introduces great flexibility requirements, complicates the ability to carry out existing tasks, and requires adding new tasks required for cooperation. This paper described the software and hardware required for such a system.

The basic system requires both movement actuation and control algorithms for datapoint entry and collision detection. The basic software was produced for a simple two-link system. The user handles the higher-level tasks. Other system features are now under development. The new datapoints are entered through the host computer while the low-level control is produced by the interface transputer running positional integral derivative algorithms. These algorithms receive their data, when available, through statements that are activated through channel input. At present, there are no provisions for

real-time operations. Movements are performed in sequence with a constant time delay.

Collision detection is achieved off line through decomposing the system into a set of spheres. The collisions are examined in terms of the relative movement of a trajectory segment and the relative time of movement. This decomposition allows dynamic collision to be quickly detected because of the inherent parallelism and uniformity of the calculation. Thus, a reconfiguration of the basic task enhanced the calculational parallelism. Similar reconfigurations were examined in other tasks. This task is accomplished at a high level and occasionally communicates with the lower-level tasks, reducing the communications overhead.

Other features already implemented include a computer-aided design (CAD) interface that allows the user to examine the movement and collision of manipulators in two dimensions. This software is resident on an Apollo system with a transputer interface. The processing is divided among several transputers. When the processing is complete, the graphical information is passed onto the high-resolution Apollo graphics routines. Trajectory points can be entered into the system and the effects examined on the CAD system. Then the control program is executed on the same set of transputers. At present, dynamic reconfiguring and loading of the transputers is being examined to enable a direct conversion from data input to control mode. The provision of the transputer on the Apollo has allowed the user to simulate, control, and develop on the same computer and environment.

The control algorithms are based on positional derivative (PD) type inputs. These algorithms can be programed easily and provide a quick first system. The PD methodology is recommended for other users. Each arm has its joints controlled by the PD algorithms resident on the interfacing transputer. Coordination between the end effectors is provided by solving the inverse kinematics of the inter-end effector error by a neighboring transputer. This configuration will reduce the accuracy of control because errors in the master sensor data and the slave are additive. However, this configuration is easily adaptable to parallel operation. These algorithms are being extended to a form of computed torque algorithm with the required integration and computation performed on a balanced set of transputers, which are determined by the profiler.

The hardware of the system is two double-link arms, interfaced to the transputer system through an inhouse analogue interface board. The interface board allows up to eight inputs, four outputs, and eight digital input/output lines. The board connects to any link of a transputer. The driver software on the transputer permits a single transputer to service up to three of these boards simultaneously, thus the system can be expanded to allow additional inputs.

The basic interface hardware system is being expanded to allow the provision for digital displacement sensors, such as resolvers, and to allow other types of robots to be controlled. The board is simple and efficient.

Real-Time Simulation and Control Applications, T.L. Ricketts, Alliant, U.K., and G. Pitt, Alliant, U.S.

The Alliant FX/Series system offers an architecture well-suited for real-time simulation and control applications. Examples of applications that have been developed on the system include:

- Boeing Commercial Future Airplane simulator
- National Center for Atmospheric Research (NCAR) Doppler Radar system for detecting wind shear
- Hughes Aircraft F/A-18 Weapons Training System.

In addition, Mazda has recently completed a full vehicle simulator for the new Miata model in which a central Alliant system controls the vehicle dynamics, window views, and instruments.

Multiple high-performance computing resources tightly coupled through a large global shared memory provide a platform in which a large complex simulation can be divided into smaller, more manageable modules. Each module can be scheduled to execute at a rate that most closely represents the actual response time of the component being simulated.

Simulation processes use the memory system for shared data and interprocess communication. Inexpensive input/output processors can be used for hardware or man-in-the-loop simulations, while computationally intensive tasks can be assigned to high performance vector processors, which may be clustered in parallel for demanding tasks.

The Alliant real-time operating system--FX/RT--provides several mechanisms to schedule and synchronize multiple processes including support for semaphores and events. Many simulations model highly complex physical systems such as commercial and military aircraft, defense weapon systems, and process control systems. Each of these physical systems contain many independent subsystems, most of which perform their functions at different rates. Several examples were presented of simulation systems operating in a symmetric multiprocessor environment with real-time software support, so that each model component can be assigned to a resource that best meets its computational needs.

Parallel Methods for Large-Scale Simulation, A.W. Burton and K. Malinowski, University of Manchester, Institute of Science and Technology and Technical University of Warsaw

This paper was concerned with the development of parallel methods for solution to large-scale systems (LSS). Attention was directed to a restricted set of LSS:

those that are adequately described by high-dimensional sets of ordinary differential equations in state-space form.

The representation of parallelism may be implicit or explicit. An implicit representation of parallelism implies that the mechanism by which concurrent processing is achieved is effectively hidden from the user. An explicit representation requires that the concurrent processes are identified explicitly by the programer. Although the implicit approach is preferable, a technical gap exists in the ability to implement implicit concurrent processing.

At the program execution level, the operating system allocates resources to potentially concurrently executable programs. At the other extreme of task granularity, at the instruction execution and bit level, the compiler characteristics are extremely important. Within the remaining concurrency levels (within the coarse to medium granularity range), central issues include the structure selection, application task scheduling, and choosing numerical algorithms. These issues must be addressed within the technical gap (with few readily available support tools).

Consequently, the systems analyst must make many crucial design decisions related to application-specific parallel processing. This paper was concerned with exploring and integrating such methods, in relation to developing concurrently executable LSS simulations.

The speaker covered the three strategies: prediscretization, discretization, and postdiscretization for parallel processing.

The techniques in the prediscretization strategy discussed were:

- Aggregation - substitute a high-order system representation by one of much smaller size, but contains the features of the physical system that are adequate for the particular problem

- Matrix partitioning - involves splitting a large matrix into several submatrices of reduced order

- Decomposition-in-time approach - involves introducing parallelism by dissecting the interval of integration. Decomposition-in-time is considered not very effective.

Discretization methods include:

- Parallel computational front method - incorporates the property of discretization into several predictor-corrector and Runge-Kutta numerical integration procedures

- Parallel block implicit method - the term block refers to a k point set of new solution estimates that are produced for each application of the algorithm. Block-implicit parallel methods are presented both in the form of a sequence of uncoupled linear multistep methods and in predictor-corrector form. The latter first predicts k discrete values concurrently, then corrects k values concurrently.

Post discretization strategies include:

- Divide and conquer - involves fragmenting a problem into smaller subproblems that may be treated independently

- Reordering - involves structuring the algorithmic sequence of a process to enhance the potential for concurrency exploitation

- Recursive reduction - a particular combination of divide and conquer and reordering

- Parallel numerical analysis - parallelism inherent in either the existing serial algorithms or the application problem itself, is extracted under the assumption of new conceptual models of how computations may proceed.

Many of the preceding approaches are not mutually exclusive and an integrated strategy of using two or more of them in a particular situation is quite feasible.

Application of Transputers to Aircraft Simulation and Control, D.J. Doorly, Imperial College

This paper described techniques for implementing an aircraft simulation and control system on a transputer network. The transputer allows great flexibility in the design of a distributed memory concurrent computer. The application of transputers in the aerospace industry lags behind systems that are usually based on either bus-connected conventional microprocessors or dedicated shared memory minisupercomputers. Developing parallel operating systems, and parallel versions of Fortran, C, Pascal, and Ada for the transputers, greatly aids in translating existing codes and provides a more open environment for code development. The work described in this paper was concerned with converting a sequential Fortran code for aircraft simulation and control to run on a transputer network.

The simulator used for this work was designed to study the handling qualities of modified aircraft configurations, in both the linear (low angle of attack) and nonlinear (high angle of attack) regimes. The simulator's second purpose was to assess the effectiveness of various control techniques to alleviate gust loads, and to optimize advanced configurations in maneuvering flight.

The simulator models the response of the aircraft to inputs from the controller and from the turbulence field. At each step, the simulator outputs the updated complete state of the aircraft to a database. This database also includes terrain and other aircraft detail. The simulator also outputs the aircraft position to a local database attached to the turbulence generator. The turbulence generator regularly updates the turbulence field and calculates the components of the local turbulent gust velocity.

The controller has a local database that accepts inputs from either the pilot or a present trajectory. The control-

ler then compares the inputs with its current estimate of the aircraft state, and sends a control to the simulator.

The techniques for parallel processing may be grouped into three principal paradigms: geometric array, algorithmic pipe, and processor farm. The latter two were used in this work. In the algorithmic pipe, each task is first examined to establish the routes along which the data processing flows and the connections between routes. A single section of data flow, between external input and output, is then treated as an algorithmic pipeline.

The processor farm uses a different approach--either the data farming or task farming methodology. In data farming, identical copies of a program (workers) are distributed across a set of processors under the control of a master program (farmer). The farmer sends data packets to the workers and collects their results. Task farming requires the master program to dynamically load tasks onto processors via the operating system and has not yet been considered for this work.

The paper concluded that the transputer-based systems offer a great scope for developing flight simulation and control strategies. Future work is expected to address nonlinear control and possible redundant hardware implementations.

Automating the Implementation of Controllers on a Transputer-Based System, F.G. Nocetti and P. Fleming, University of Wales

The work reported in this paper arose from the authors' previous work on mapping strategies for implementing controllers onto transputer networks. This effort stimulated research into the development of software tools to automate the process.

The MATLAB is a collection of software tools for use in linear algebra, matrix manipulating and computing, and numerical analyzing. The MATLAB tools developed in this work obtain a parallel representation of the original control algorithm. The software accepts a continuous controller description in block diagram form and performs the partitioning, discretizing, and state-space parallel representing of the system.

A MATLAB tool called *blkedit.m,* developed to ease controller information output, transforms the control law into several independent tasks. *Blkedit.m* obtains the relationship between each input and output variable, and reduces each of these input/output relationships to a set of independent path transfer functions. The high-order path transfer functions generated during partitioning are expanded into partial functions. The resultant functions are discretized and finally represented in state-space form. The whole process is automated by using a specially developed function called *paradata.m*. *Paradata.m* also produces an output database that includes the state-space data and the controller connectivity for further

parallel processing by the Occam tools within the transputer development system (TDS).

The Occam tools, developed in the TDS, automate the mapping of the controller tasks onto several transputer-based topologies, using either static or dynamic task allocation strategies. The tools also permit simulating and evaluating both strategies by displaying processor activity and performance.

Real-Time Simulation and Control of Power Systems, T. Berry, A.R. Daniels, and R.W. Dunn, University of Bath

Work at the University of Bath has proceeded from optimal control studies for a single generator to the simulation of complex multi-machine power systems. Early work showed that power system simulation could be divided into several concurrent processes. At the highest level, user interaction and graphical output can run concurrently with the main calculation model. The model has concurrency between the individual generators. This concurrency can be exploited by a computer system using several processing units. With multiple microprocessors, a power system simulator can be built with dedicated hardware giving reasonable performance at low cost.

A system was built that included six 16-bit, single-board computers. This system successfully modeled a four-machine, six-busbar study in real time. An enhanced computer using eleven 32-bit processing nodes could model systems with up to 20 machines and 60 busbars in real time. Both systems produced comparable responses to studies performed using a Central Electricity Generating Board mainframe transient simulation package.

The simulator software is now running under Helios on a system consisting of an IBM PC/AT compatible personal computer fitted with one transputer board and a second display card. Early work with multiple transputer systems indicates that three T800 processors will be able to simulate the 20 machine study.

Transputers for Robotic Control, H. Mirab and P.J. Gawthrop, University of Glasgow

In robot control, partition of the computational tasks between various independent processors that can operate in parallel and communicate with each other when necessary, can ease the computing burden and allow real-time implementation of a desired control algorithm. Better performance can be achieved by exploiting the inherent parallelism of the algorithm first. Then devising a suitable processor topology can be devised that matches the number of processes and has identical communication structures, in relation to the developed parallel algorithm.

When implementing a robot control algorithm, simplifications are usually made, such as ignoring the centrifugal and coriolis forces created by the coupling of the

dynamics. In addition, each joint is treated as a decoupled system. Because of resulting performance limitations, and the need to include the dynamic equations as a whole, parallel computation is chosen to allow real-time implementation.

Most applications utilizing parallel processing for the calculation of the dynamic equations of robot manipulators are based on a formulation for articulated chain dynamics. These calculations yield a set of recursive equations for the dynamic components consisting of forward and backward phases.

The two basic approaches are dedicated multiprocessor approaches. One approach breaks the computation into a series of subtasks for execution on independent loosely coupled processors. In the systolic architecture approach, tightly coupled processing produces the computation.

The Measurement and Production Control of Woven Mesh, G.S. Virk, P.W. Wood, and I.D. Durkacz

In the weaving industry, the simplest hardware configuration consists of a commercially available transputer-based image processing/frame grabber card residing in an IBM compatible PC. The card is connected to the camera and a display monitor. Additional transputers can be connected to the frame grabber card through standard Inmos links. The image processing software, written in occam 2, is developed under the TDS, and loaded onto the transputer network using a custom written Pascal server. The occam program performs the entire sequence of operations from initial image capture, through image processing, to the final calculation and display of the mesh parameters. After the image is captured, it passes through the following processing steps: normalizing, thresholding, weft extraction, and mesh parameters calculation.

The instrument is limited to dealing with meshes that are single layer. Work is continuing to improve the current system, as a fully developed system would be valuable.

INFORMATION TECHNOLOGY

ESPRIT - A Guide to Structure and Literature

by Robert D. Ryan

Frequent readers of European Science Notes Information Bulletin (*ESNIB*) will realize there have been many articles on aspects of the European Strategic Programme for Research and Development (R&D) in Information Technology (ESPRIT)[1]. People familiar with the publications of the Commission of the European Communities (CEC) will have noticed that the information in these articles is usually available directly from ESPRIT publications. The purpose of this, yet-one-more article about ESPRIT, is to review highlights of ESPRIT philosophy, to describe briefly the ESPRIT process (organization, management, and review), and to provide a guide to the ESPRIT documentation. This literature is complete and easily obtained.

The material for this article comes from three sources: my notes from a talk on ESPRIT by the Director of Information Technology, ESPRIT, Jean-Marie Cadiou, given at the National Academy of Sciences, Washington, DC, January 1990; my notes taken on a recent visit to the people who manage ESPRIT in Brussels; and several ESPRIT publications. I will describe these publications in the article.

Why ESPRIT?

Funding for ESPRIT is a small percentage of the total amount spent on information technology (IT) by the 12 member states of the European Community (EC). So why is ESPRIT so important? The ESPRIT acts as the central nervous system for R&D in IT in Europe and it exercises considerable leverage on IT research in Europe. The ESPRIT funding is eagerly sought and difficult to win. The success rate for Basic Research Actions is about 1 in 7. The ESPRIT funding carries considerable prestige in the European IT community. In some mem-

ber states, support for basic research in computer science depends almost completely upon ESPRIT. Most of the important IT research groups in Europe are active in one or more ESPRIT projects.

History

The ESPRIT is the EC strategic response to economic realities: the key role of IT in most economic activities for now and the future, and the problems with European IT industry in the early 1980s. One of today's economic landmarks is that IT is about the fastest developing sector, with annual growth projected to continue at 15-25 percent into the 1990s. The IT is a major industry in itself and it contributes to the competitiveness of most other economic activities. Also, IT is a driving force for social change, with applications in education, health care, the environment, and the arts. Further, IT is central to modern military technology. Although European IT markets represent a large and growing segment of world demand, European industry has been in a weak position in several sectors. The ESPRIT was defined as a European IT strategy after an assessment undertaken by the EC in close cooperation with industry in 1980. The ESPRIT was to overcome the following problems: scattered R&D efforts, lack of university/industry cooperation, and suboptimal size of markets and enterprises. The latter was largely because of the fragmentation into national markets and the practice of national preferences, resulting in insufficient economies of scale[2].

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[1]See, for example, *ESN* 37-12 (1983), 38-02 (1984), 38-05 (1984), 39-01 (1985), 39-06 (1985), 40-01 (1986), and 40-11 (1986); *ESNIB* 88-01, 88-03, 88-04, 90-01; and ONRL Report Nos. R-11-84 and R-13-84, and ONREUR Report No. 90-1-R.

[2]As an illustration, consider the combined postal, telephone, and telegraph (PTT) systems of the member states. The supplier of equipment sold only to the national PTT and the national PTT bought only from national suppliers. Furthermore, there were (and are) monumental economic and social/cultural barriers against change. One need only look at the number of people involved directly and indirectly in a national PTT to assess the forces in favor of the status quo: owners, managers, workers in the supply industry; government managers and workers in the PTT; labor unions for workers in both the PTT and supply industry.

The EC officially launched ESPRIT on February 28, 1984, as a 10-year program, divided into two 5-year phases. The three objectives were to:

1. Provide European IT industry with the basic technologies to meet the competitive requirements of the 1990s

2. Promote European industrial cooperation in IT

3. Contribute to developing internationally accepted standards[3].

The first phase, ESPRIT I, cost $1.8 billion and ran from 1984 to 1988. The second phase, ESPRIT II, 1988-1992, is estimated at $3.3 billion. Note this is total funding. Half of the cost is paid from the EC budget and half is paid by the participants.

ESPRIT Language, Philosophy, and Ground Rules

The ESPRIT has its own language. To emphasize the use of certain words, I will follow a convention used in some ESPRIT publications: terms that have a specific meaning in the ESPRIT context are printed bold on their first appearance. They will often be capitalized.

The ESPRIT is implemented through precompetitive **R&D Projects**. The ESPRIT **Workprogramme** describes topics that Projects address; it also describes the strategy, objectives, and technical aspects of the work. The Workprogramme is updated regularly in consultation with the European IT community. The Official Journal of the EC publishes **Calls for Proposals**.

The Workprogramme distinguishes between two types of projects: **Type A projects** are individually described in the Workprogramme with their specified intermediate and long-range objectives; **Type B projects** are not individually described in the Workprogramme. Readers familiar with Office of Naval Research (ONR) programs can roughly equate Type A projects to Accelerated Research Initiatives and Type B projects to Core programs.

Each ESPRIT **Project** is carried out by a **Consortium** under a shared cost contract with the CEC. The Consortium has technical and financial responsibility for the performance of the work. The CEC monitors and evaluates the achievement of objectives, management effectiveness, and industrial relevance of projects. This is done through a **Project Officer** (a CEC employee) appointed by the CEC to liaise with the Consortium.

A Consortium consists of **Partners** who jointly make a Proposal to the CEC. If the Proposal becomes a contract, the Partners are called **Contractors**. One of the Contractors will be responsible for coordinating all communications with the CEC. This is the **Coordinating Contractor**.

Associate Contractors are project participants who normally either make smaller contributions to a project, or who do not require the full exploitation rights to all results, or who do not wish to bear joint and several responsibilities for completion of the project.

Contractors may be companies, including small- and medium-sized enterprises, universities, and other bodies established in the EC or in non-EC countries that have concluded agreements for scientific and technical cooperation with the EC.

The most important ESPRIT ground rules are:

● Each Consortium must include at least two independent industrial organizations from the EC, not established in the same member state

● The Proposal must be for a precompetitive R&D project to be undertaken in a period of 5 years or less.

The CEC attaches considerable importance to the participation of small- and medium-sized business[4], and has made provisions to help these organizations participate in ESPRIT. The EC would like to see some of these businesses develop into the likes of Sun and Compaq. Enterprises like these are conspicuously missing from the European IT landscape. There is also a policy to allocate no more than 30 percent of the EC's total contribution to projects that fall below a threshold of 100 man years of effort.

The ESPRIT Basic Research Actions and Working Groups have slightly different language and rules. These are discussed below. The ESPRIT managers place high value on intercountry cooperation among partners. One has the impression from discussions in Brussels that cooperation sometimes has higher priority than the Project's content. The EC takes a long view and is serious about building a pan-European research structure.

European Free Trade Association (EFTA)

The EFTA member states (Austria, Switzerland, Iceland, Norway, Sweden, and Finland) can participate in ESPRIT in two ways[5]:

1. By becoming directly associated with ESPRIT as a result of signing an agreement with the EC, in which case

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[3]I have seen a slightly different wording of this objective, namely: to pave the way for standards. I mention this not to put too fine a point on wording, but to recognize that this objective has created some discomfort in IT industries outside the EC.

[4]A small- and medium-sized organization is one that fulfills the following criteria: has less than 500 employees, has net annual turnover of less than 38 million ECU, and not more than one-third of the ownership is ascribed to a parent organization or financial institutions.

[5]EC watchers will be aware of the controversy surrounding negotiations between EFTA states and the EC regarding the extent to which EFTA countries will participate in the EC's single market and the amount of influence EFTA will have in shaping future EC policy.

the partners from the EFTA countries can participate under the same conditions as partners from the EC

2. In other cases, there will exist only a general framework agreement covering scientific and technical cooperation between the EFTA country. A specific decision is made to permit partners from the country to participate in a project on condition that they pay 5,000 European Currency Units (ECU) for the general cost of the project. The EC does not contribute financially to the research costs of these participants.

As of 30 March 1990, Austria participates in 7 projects, Finland participates in 10 projects, Norway participates in 12 projects, Sweden participates in 21 projects, and Switzerland participates in 17 projects. Iceland has yet to participate in ESPRIT, although it is involved in other EC projects.

Participation of an EFTA country in a Consortium does not fulfill the requirement for two industrial partners from different member states.

Proposals, Evaluation, and Selection

The ESPRIT proposal preparation, evaluation, and selection have many points in common with the processes at the National Science Foundation, ONR, and other U.S. funding agencies. I have the impression that the ESPRIT processes are somewhat more structured. This perception is based on the literature and discussions with ESPRIT contractors.

I describe here the two publications essential to the proposal process. They are written as guides for proposal preparation. They also contain a wealth of information on the content and process of ESPRIT.

ESPRIT Information Package. This provides details on submitting proposals, including formats for all required information. The package contains general information about ESPRIT projects, information on evaluation and selection, and notes on contract conditions and costing principals.

ESPRIT Workprogramme. The *Information Package* tells how to do business with ESPRIT; the *Workprogramme* tells what work will be done. Note there are two brochures for the 1989 *ESPRIT Workprogramme*: one dated May 1989 covers Microelectronics and Peripherals and the other, dated July 1989, covers Information Processing Systems, Office and Business Systems, and Computer-Integrated Manufacturing (CIM). These brochures provide a good introduction to the content of the ESPRIT programs. For each sector there is a discussion about the importance of the sector, an analysis of the main work underway, and a discussion of specific priorities for the sector. (Information Processing Systems is an example of a sector.)

Next, the sectors are broken into subareas and detailed descriptions of appropriate work are presented. For example, under Information Processing Systems one finds six subareas: Systems Engineering, Knowledge Engineering, Information Servers, Advanced Systems Architectures, Human Computer Interfaces, and Sensor-Based Systems. As an example, work on the Portable Common Tool Environment (PCTE) is described under Systems Engineering, while Generic Fault Tolerant System Architecture and Neural Computing are topics under Advanced Systems Architectures.

Reading the *ESPRIT Workprogramme* gives one a quick look at ESPRIT programs and priorities. The *Workprogramme* does not contain proposed funding levels. I present some funding information below under Statistics.

Finally, there are the official *Calls for Proposals*. The EC publishes these in the *Official Journal of the European Communities*. Calls are published periodically and refer to specific programs described in the Workprogramme. Once a call is published, the proposal must be sent to Brussels. Publishing the Workprogramme ahead of the official call gives researchers time to organize consortia and to prepare a proposal in advance of the call. At least that is the theory.

Statistics

The ESPRIT is by far the largest "line item" in the total EC R&D effort--the Framework Programme--for the period 1987-1991. Consequently, ESPRIT accounts for 1,600 million ECU out of a total budget of 5,396 million ECU. The next largest item is less than half this size.

Participants

Universities and research institutes participate in 75 percent of the projects, and users participate in 37 percent of the projects (see Table 1).

Table 1. Participants	
Large Companies	254
Small/Medium Companies	278
Universities/Research Institutes	317
Users	184
	1,033

Table 2 indicates the funding allocation for the 1989 ESPRIT Workprogramme.

Table 2. 1989 ESPRIT Workprogramme Funding Allocation	
Information Processing Systems	270 million ECU
Systems and Knowledge Engineering	50%
Advanced Architectures	25%
Systems Integration	25%
Office and Business Systems	170 million ECU
Integrated Applications	35%
Workstations	25%
Distributed Systems and Communications	40%
Computer-Integrated Manufacturing (CIM)	100 million ECU
CIM Architectures and Communications	30%
Systems and Product Design	20%
Management and Control	25%
Robotics and Shop Floor Systems	25%

The *ESPRIT Information Package* published these numbers in the issue dated September 1989. This represents about 50 percent of the total cost, the other 50 percent coming from the Contractors.

Basic Research Actions and Working Groups

While ESPRIT I was becoming a major success in promoting cooperation on precompetitive research, there was a growing consensus within ESPRIT that supporting basic research in IT is a solid investment with considerable payback, even if it does not come in the form of short-term industrial applications. This position is widely held in the U.S., and in fact, the level of U.S. funding for IT basic research is quoted in the EC literature rationalizing the establishment of a basic research program within ESPRIT II.

The EC managers also realized that the ESPRIT I groundrules excluded important work being done at universities and research institutes. At the same time, public funding for basic research in national programs was decreasing with the growing emphasis on industrially oriented research.

After considerable debate by leading European researchers, the ESPRIT management adopted these objectives for the first ESPRIT Basic Research Actions:

- To support collaborative fundamental research in selected IT areas
- To increase the involvement of leading research teams in ESPRIT.

In keeping with the ESPRIT spirit, it was agreed not to spread limited resources thinly over all possible areas of interesting, or even exciting research, but to establish criteria to define the scope of the Basic Research Actions. Thus Basic Research Actions should:

- Have the potential to produce future breakthroughs or important advances even though they might not have any immediately visible applications
- Fall into areas where collaborative research on a European scale brings added value
- Be clearly upstream from main precompetitive R&D.

Basic Research Actions operate under modified groundrules. Most significantly, it is not necessary to have two independent industrial partners in different member states. Two of the partners must come from different countries, but they need not be industries. They may be universities, research institutes, or industrial research laboratories.

The first Call for Proposals came on March 25, 1988. By the deadline, about 300 proposals were received, representing requests for 485 million ECU for a total research effort exceeding 1 billion ECU. This response was much greater than expected. The proposals were of generally high quality and involved most European teams working in the forefront of basic IT research.

After evaluation by the CEC and recommendations by the ESPRIT Management Committee and by the ESPRIT Advisory Board, 61 proposals involving 285 different organizations were funded. In addition, 13 proposals were joined in working groups and given limited support to facilitate cooperation through travel and workshops. This latter action underlines the importance that ESPRIT management places on cooperative efforts.

Future Basic Research Actions will be selected to:
- Maintain dynamic coverage of key areas
- Reinforce interdisciplinary links which open new ways of looking at major problems
- Ensure that the scarce qualified manpower needed for basic research is available
- Make certain that the results of research are transferred downstream to industrial research.

The ESPRIT takes this last point seriously, and to this end requires that each action hold a workshop once a year. Invitations are issued to participants in related Basic Research Actions and to industrial researchers who can provide feedback on the suitability of the results for addressing industrial problems. Some workshops will encompass activities of several actions in related areas. They also will be focal points for developing special training schemes on emerging topics where qualified manpower is scarce. Funding for Basic Research Actions is about 10 percent of the budget. However, I was told that basic research is increasing.

Literature

I believe that ESPRIT has the best documentation of any similar program with which I am familiar. The EC approaches the problem of "getting the word out" seriously and devotes the resources necessary to get the job done well.

Unless otherwise noted, the documents described below can be obtained from:

ESPRIT Information Desk
Directorate General XIII/A-2
Commission of the European Communities
Rue de la Loi 200
B-1049 Brussels
Belgium
Tel: +32.2.235.16.03.

I have already described the *ESPRIT Information Package* and the *ESPRIT Workprogramme*. Note, there may be more than one brochure covering the total Workprogramme, and there is a separate brochure, *ESPRIT Basic Research Actions Information Package*, for the basic research program.

EC Research Funding, A Guide for Applicants. This is not an ESPRIT document. The document covers all of EC R&D programs, which collectively come under the Framework Programme[6]. I include this brochure because it provides a good introduction to the EC thinking about R&D and embeds ESPRIT in this larger picture. This brochure is published by Directorate General (DG) XII, the same address as above.

ESPRIT General Brochure. This 15-page brochure gives a quick look at ESPRIT, including brief background, philosophy, and research highlights. The brochure contains addresses for further information.

ESPRIT Project Synopses. This set of 8 volumes provides a comprehensive view of ESPRIT projects. The volumes are subtitled:

1. Index of Projects and Programme Overview

2. Microelectronics and Peripheral Technologies

3. Information Processing Systems - Part I: ESPRIT I Projects

4. Information Processing Systems - Part II: ESPRIT II Projects

5. Office and Business Systems

6. Computer-Integrated Manufacturing

7. Information Exchange System

8. Basic Research Actions and Working Groups

Volume 1, Index of Projects and Programme Overview, contains an introduction to ESPRIT and several

pages on each of the major research areas. (These are more fully described in Volumes 2-8.) There are two master indices of the projects: one by project number and one by acronym. Volume 1 also contains two lists of the participating organizations: one for industry and one for universities and research establishments. Thus, one can look down the list to, say Thomson-CSF, and see all the projects in which Thomson-CSF participates.

Volumes 2-6 are each structured the same way. Each volume has a complete list of projects by project number and title and a list by acronym and title. There is a one-to-two page description of each project, beginning with the project objective and usually including a brief discussion of work-to-date, or if a new project, perhaps some indication of how the work is embedded in the larger field of IT. This is followed by the name, address, and telephone number of the point of contact, and a list of the project participants. The project start date and duration are at the end of each writeup.

Volume 7 has the same format as Volumes 2-6, but the content is different and merits special mention. When ESPRIT was established, the Council of Ministers required that, in addition to the work defined in the main technical areas, supporting actions be taken to ensure that the execution and management of the R&D projects were properly supported and that the results were appropriately disseminated. The result was the ESPRIT communications infrastructure, called the Information Exchange System (IES). The 8 projects described in Volume 7 contribute to current and future electronic communication, with emphasis on Open Systems Interconnections (OSI)-conformant communications. The center piece is EuroKom, Project Number 706. The EuroKom project provides a centralized computer service to terminal and personal computer users, supporting research teams, and business and government organizations in their national and international communications in all member states and from other sites within Europe and beyond. EuroKom is the dedicated communications network for ESPRIT and is operated for the CEC by University College Dublin.

Volume 8 is devoted to the Basic Research Actions and Working Groups and has the same format as Volumes 2-6. This is the key source for information about the basic research being done under ESPRIT.

ESPRIT 1988 Annual Report. This 110-page, large format brochure presents highlights of material found in the *ESPRIT Project Synopses*. The report also contains a bibliography of ESPRIT documentation. This is the brochure to read if one has limited time or interest because it presents a good overview of history, philosophy, research, and results.

The Review of ESPRIT 1984-1988. This is a report on the study conducted by the independent review board on

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[6]See *ESNIB* 90-02 for an overview of the Framework Programme.

ESPRIT between October 1988 and May 1989. In 39 large format pages, it tells what is right and what is wrong with ESPRIT. This report contains an executive summary (Key Observations and Conclusions), and the report itself is a summary of the Extended Report of the ESPRIT Review Board. The review touches upon most aspects of the management and the content of ESPRIT, with a bias towards management issues. The ESPRIT Review Board (ERB) begins by reviewing the IT industry in Europe as a background for judging ESPRIT, and continues by looking at the major issues. Both research managers and bench scientists will recognize the issues discussed--program development, relevance, transition, communication, number of partners in a project, delays in contract negotiations, speed of payments, and so on. Managers from funding agencies in the U.S. and their contractors will find many parallels between the concerns raised by the ERB and their own experience.

Newsletters

The DG XIII publishes, or has published, several newsletters. These provide up-to-date information on general aspects of the IT industry in Europe as well as information on topics of interest to ESPRIT participants. I list two here.

1. *Information Market* covers many aspects of the IT industry. For example, a recent issue contained information on European databases. *Information Market* is available by writing to:

Information Market
P.O. Box 2373
L-1023 Luxembourg
Tel: +352 48 80 41
Fax: +352 48 80 40

2. *iesnews* is the newsletter of the ESPRIT Information Exchange System, which I described above under Literature. *iesnews* is published on behalf of the DG XIII and can be obtained by writing to the editor, Peter Popper at:

European Institute for Information Management
13, rue de Bragance
L-1735 Luxembourg
Tel: +352 44 58 11
Fax: +352 44 73 52
E-Mail: peter_popper@eurokom.ie

Further information is available from the ESPRIT information desk.

Annual ESPRIT Conference

Project participants, industrialists, and government policy makers meet each year at the ESPRIT Conference to discuss the results, achievements, and impact of the ESPRIT program. The week-long conference is held in Brussels in November and attracts around 2,000 participants. The events include:

- A 3-day technical conference during which participants present papers in plenary and parallel sessions
- The IT Forum day where European decision makers present their views on the prospects for the European IT industry (see ONREUR Report 90-3-C)
- A presentation of the present status of the ESPRIT II program including Basic Research Actions
- An exhibition demonstrating project results.

Proceedings of the Annual ESPRIT Conference are available from:

Kluwer Academic Publishers Group B.V.
7-11 Kamerlingh Onnesweg
P.O. Box 322
3300 AH Dordecht
Netherlands

The volume for 1989 costs £94 (about $160). There is also a charge for the past year's proceedings. Other cited documentation is free.

Summary

The ESPRIT is the single most important computer science and IT research program in Europe. The importance stems not so much from the total volume of funding as from its strategic position and leverage. This note presents a quick introduction to ESPRIT and the ESPRIT documentation. I feel that U.S. IT researchers should be familiar, at some level, with the ESPRIT process and content, and that the best way to do this is to explore the ESPRIT documentation.

MATHEMATICS

Topics in Computer-Aided Geometric Design-90

by Richard Franke, formerly the Liaison Scientist for Mathematics and Scientific Computing in Europe and the Middle East for the Office of Naval Research European Office. In September 1989, Dr. Franke returned to the Naval Postgraduate School, Monterey, California, where he is a Professor of Mathematics.

Introduction

The Ettore Majorana Centre for Scientific Culture (Center) was founded in 1963 to "give life to a completely new way of realizing the EAST-WEST-NORTH-SOUTH collaboration, without discrimination and above any ideological, political, or racial barrier." The Italian Ministry of Education, the Italian Ministry of University and Scientific Research, and the Sicilian Regional Government sponsor the center, located in Erice, Sicily. The center is named for an Italian theoretical nuclear physicist, of whom Enrico Fermi said " ... and then there are the geniuses like Galileo and Newton. Ettore Majorana was one of these."

Computer-Aided Geometric Design (CADG)-90 was held on May 12-19, 1990, under the auspices of the International School of Mathematics, "G. Stampacchia." In addition, there are more than 90 other schools at the center that regularly sponsor meetings in all branches of science. Particular meetings may have some industrial or academic sponsorship in addition to that provided by the center, although there was no other financial support for CAGD-90. The Center is located in the premedieval village of Erice, atop a 750-m high mountain in the northwest part of Sicily, near Trapani. The physical facilities consist of two restored monasteries and the ancient Palazzo Ventimiglia (formerly the residence of the Viceroys of Sicily, and later a convent named after San Francesco). The village is small and very isolated, the entire atmosphere being conducive to intensive discussions in a workshop setting.

The CAGD-90 workshop was organized by Michel Bercovier, Hebrew University of Jerusalem, and Vincenzo Capasso, School for Advanced Studies in Industrial and Applied Mathematics (School), Bari, Italy. Added organizational help was given by R.E. Barnhill, Arizona State University; Wolfgang Böhm, Technical University of Braunschweig, Federal Republic of Germany (FRG); Josef Hoschek, Technical University of Darmstadt, FRG,

as well as F. Giannessi, Director of the School; and A. Zichichi, Director of the Center. The purpose of the meeting was "to make an authoritative review of the subject to date as well as to develop new topics." Participation was by invitation only, with 43 persons attending.

To enable young researchers with limited or no access to travel funds to attend the meeting, the Office of Naval Research European Office provided a grant of $4,000 to a committee. The committee was made up of W. Böhm, J. Hoschek, H. Hagen, with me as an advisor. From this grant, the committee allocated funds to seven young researchers. (1) Mateus Eck will soon finish the Ph.D. at the Technical University of Darmstadt. (2) Bernd Hamann is a student from Germany working on the Ph.D. at Arizona State University, Tempe. (3) Panagiotis Kaklis is a postdoctoral fellow at the Technical University of Berlin and will soon return to Greece. (4) Helmut Pottmann is visiting the University of Kaiserslautern from the Technical University of Vienna and will visit Purdue University, Lafayette, Indiana, next year. (5) Franz-Josef Schneider is working on the Ph.D. at the Technical University of Darmstadt. (6) Guido Schulze just finished the Ph.D. at University of Kaiserslautern, FRG. (7) Peter Wassum is working on the Ph.D. at the Technical University of Darmstadt.

The Program

During the meeting, 30 talks (mostly one hour long) were presented. Because of Italian bank and other service agency hours and leisurely meal service (some of those less appreciative would say lackadaisical or even just poor service; proper appreciation of this aspect of Italian life requires the correct mind set), it is unlikely that any one person heard all talks. I missed several talks because the meeting actually started before I had arrived, and I had to make arrangements for leaving the island at a travel agent open only during times talks were given. Consequently, in a few cases, I have only provided a title

and author of a lecture. The length of my comments for a particular lecture reflect more about my interest and perceptions than any objective analysis concerning the importance of the lecture.

The talks are listed in the order they were given.

Surfaces on Surfaces, Robert E. Barnhill, Arizona State University.

2-Surfaces in n-Space, Christoph Hoffman, Purdue University.

A Simple Pipe Model of Low Order, Michel Bercovier, Hebrew University of Jerusalem.

Practical Aspects of Multivariate Polynomial Interpolation, Carl deBoor, University of Wisconsin. deBoor discussed the computational aspects and possible behavior of the multivariate polynomial interpolation scheme he discussed about one year ago at Oberwolfach, FRG (see *ESNIB* 89-09:35). After some detail about the "least" function (all of the lowest degree terms in the Maclaurin series expansion of the function) and how a certain inner product with the exponential function gives point evaluation of polynomials, he discussed in detail an algorithm for construction of the interpolation polynomial. The construction is based on Gauss elimination with pivoting, but treats columns corresponding to a given degree simultaneously. The elimination process results in orthogonal vectors corresponding to the "appropriate" basis. Zeros are replaced by orthogonality between entries within columns corresponding to a given degree (although zeros may appear in the case of well-advertised degeneracies that can occur). One interesting special result concerns the behavior of the Lagrange polynomials. In the univariate case, not all can be positive at once, and because they sum to one, the Lebesque function (sum of the absolute values of the Lagrange polynomials) is bigger than one except at the nodes, and this implies possibly poor behavior of the interpolant. In the bivariate case, there may be a considerable region over which all Lagrange polynomials are positive. deBoor hastens to add he does not necessarily advocate high-degree polynomial interpolation. He has computed with as many as 100 points in the plane, implying terms as high as degree 13 are involved. The process is as continuous "as is possible," but the approximating space may change abruptly as points move, and since computations are done in finite precision, certain configurations may cause some difficulty. A report is available (deBoor and Ron).

Polar Forms and Multivariate Splines, Wolfgang Dahmen, Free University of Berlin (joint with H.-P. Seidel and C. Micchelli). A difficulty with attempting to use multivariate B-splines for approximation purposes is that the approximating space is underdetermined. This paper considered the construction of a "reasonable" basis to be used for approximation. The construction involves the association of a "cloud" of additional points with each data point and a subsequent choice of the B-spline basis from the resulting space.

B-Spline Basis Conversion and Left Inverses, Tom Lyche, University of Oslo (joint with Knut Mørken and Kyrre Strøm). The process of knot insertion and removal was considered. The goal was to perform the operations in such a way that the norm of the process was as small as possible.

Rational Curves and Surfaces, Gerald Farin, Arizona State University, Tempe. This talk revolved around several ideas. First, Farin discussed the construction of rational curves interpolating points, slopes, and curvatures, then moving to representation of conic curves as rational spline curves. His point of view is that designers have little interest in order of convergence or rational cubics. However, that they would like to reproduce conic curves (perhaps especially circular arcs); hence, conic precision is more important than polynomial precision.

His final topic was different and involved using the Clough-Tocher element for interpolation on a triangular mesh of arbitrarily spaced (scattered) data. A C^1 interpolant can be achieved with arbitrary specification of derivative data at the vertices. Farin and a student are working on the idea of using the parameters to attempt to achieve as near to C^2 continuity as possible. In the process, the imposition of linear cross boundary derivative is relaxed, but without compromising C^1 continuity. The process is performed locally, and then iterated. In some cases, precision for cubics has been obtained, but they do not yet know whether the present algorithm will always converge to a parent cubic.

Circular and Spherical Splines, Josef Hoschek, Technical University of Darmstadt. Because of the usefulness of circular arcs in milling and pipeline construction, Hoschek considered the construction of G^1 curves made up of circular arcs. He approached the construction by using rational quadratic control points. He considered both the case of interpolating and approximating curves for data in the plane. He constructed two circular arcs that made G^1 contact with two skew lines (and each other), useful for piping problems. The interpolatory work was extended to piecewise circular arcs on the sphere, first using only great circles, then using smaller circles. The talk ended with some discussion of similar splines on other surfaces such as quadrics, ellipsoids, and hyperboloids.

Bézier Patches on Quadrics, Wolfgang Böhm, Technical University of Braunschweig (joint with Dianne Hanford, Arizona State University). This talk considered the construction of Bézier patches defined on quadric surfaces.

Algorithms for Rational Composition, Tony DeRose, Washington University (joint work with Ron Goldman, Hans Hagen, and Stephen Mann). There are many applications that are special cases of composition of rational curves expressed in Bézier or B-spline form. Among them are reparameterization, subdivision, evaluation, knot insertion, deformation, degree raising, and conversion between tensor product and triangular Bézier patches. In certain instances, the map may not be unique, but DeRose discussed two methods: (1) the multi-affine method, where the composition is done in the higher dimensional polynomial space and then projected to the rational space; and (2) project to the rational space first, and then construct the composition.

Geometric Continuity in Automotive Surface Design, Ray Sarraga, General Motors Research Laboratory, Warren, Michigan. Sarraga discussed problems with representation of auto body surfaces (his illustration was the inner panel of a door). Beginning with scan data along lines, Bézier patches are constructed. When the rectangles have a high aspect ratio (especially), it is possible for the patch to have very poor behavior in the interior. This results from continuity conditions forcing the control points to be overlapping, or near overlapping. Sarraga would welcome solutions to the problem.

Curve Mesh Fairing and GC^2 Surface Interpolation, H. Nowacki, Technical University of Berlin (joint with P. Kaklis and J. Weber). Nowacki is a naval architect and discussed the problems of constructing a ship hull surface from traditional ship lines. The curve mesh is first smoothed using minimization of an appropriate functional involving smoothness (a pseudonorm involving derivatives) and fidelity to the given data (see Kaklis, page 16). The surface is then filled in with patches that are degree 3x5 in a checkerboard pattern.

Topological Surfaces in a CAD System (UNISURF V), Franscis Le Breton, Matra Datavision, Les Ulis, France. Le Breton presented UNISURF's history from the first version written in machine code running on a machine with 4K bytes of memory and driving a homemade drafting machine, but concentrating on the present version. The UNISURF goal is to model all parts (say of an automobile) including the sheet metal, the foundry cast items, forged parts, and plastic. In addition, it can perform meshing for finite-element analysis of the parts and generate the instructions for numerically controlled milling of molds.

Data Dependent Triangulations and (lack of) Barycentric Coordinates for S^2, Andrew Worsey, University of Carolina, Wilmington. Dyn, Levin, and Rippa's recent work has shown that if dependent variable data is considered for a piecewise linear approximation to a function, the optimal triangulation (one minimizing the maximum error for the interpolant) is dependent on the data, and possibly far from the usual idea of optimal (the Delaunay triangulation). This work was based on a one-dimensional idea, being based on edges in the triangulation. Worsey proposed that a higher-order dependency be used, minimizing the sum of the squares of the differences between the normal to the surface at the vertex and that of the surrounding linear pieces. Examples showed that the method works well, especially when the function has creases or other such features. The second part of the talk concerned the possibility (or impossibility) of barycentric coordinates on the sphere. Given a triangle on the sphere, the edges being geodesics, using the ratio of areas of triangles as in the planar case does not work in the sense that the ratio of areas as the point approaches an edge is not the same as the ratio of the edge lengths. He investigated other possible meanings, but with pessimistic results for the existence of barycentric coordinates on the sphere that preserve the desirable properties of the system.

Surfaces on Surfaces, Tom Foley, Arizona State University. Foley discussed the problem of constructing scattered data interpolants on the sphere. Since there are several scattered data interpolants for scattered data in the plane, one method he discussed was to map the sphere to a rectangle, do the interpolation in the plane, and then map back to the sphere. This presents some problems. To do it just this way, one must have periodicity along constant latitude lines, and constant value along the edges corresponding to the poles. His solution was the following: perform the mapping twice, first cut at the usual *international dateline*, map to a rectangle and construct an interpolant Q_1; then rotate the poles to an east-west position with the *international dateline* lying along the equator (but not intersecting the dateline in the previous case), map to a rectangle and construct interpolant Q_2. The final interpolant is formed by taking a C^1-weighted average of the two interpolants mapped back to the sphere, the weight functions being zero at locations where difficulties occur (that is, the poles and the international dateline for the interpolant with which they are respectively associated). In this way, a C^1 interpolant is obtained. In a similar manner, cylindrical domains and toroidal domains can also be handled.

Interpolation on Surfaces using Minimum Norm Networks, Helmut Pottmann, visiting University of Kaiserslautern from Technical University of Vienna. Pottmann generalized the idea of minimum norm networks contributable to Nielson (1983) to arbitrary manifolds in space. First, a suitably accurate piecewise linear triangulation of the domain surface was constructed. The independent coordinates of the scattered data may or may not lie on vertices of the triangulation. If not, the triangulation is altered so that each data point is at a vertex of the triangulation of the domain. Not all vertices of the triangulation are data points, however. The unknown values are estimated by minimizing a network of lines, minimizing the integral over the triangle edges of the slopes squared. Derivatives at the vertices are then estimated by constructing a network of curves over the triangulation that minimizes another pseudonorm, the sum of the integrals over the triangle edges of the square of the second derivative of the curve network. In each case, the system of equations is sparse and solved by Jacobi iteration. The curve network is made up of cubic curves. Then, using these values and derivatives, the interpolation function is constructed as a piecewise function over each triangle. The triangle is projected into the plane tangent to the (domain) surface, and a side-vertex method is used to construct the interpolant. This function may not interpolate the curve network. Pottmann also mentioned visualizing such a function by considering it to be a function of three independent variables in 4-space. He showed some interesting slides that were surfaces in 3-space generated by projecting the 4-d surface into 3-space; for example, the (w,x,y,z) surface was projected into (x,y,z) and the surface displayed. These pictures were interesting, but the proper interpretation of them seems to require some thought.

Solution of a Wire Path Problem, Charles Micchelli, IBM Watson Research Center, Yorktown Heights, New York. Micchelli discussed the solution of a problem concerned with the shape of a deformed wire subject to continual wear caused by external forces and surrounding material. The application is to dot matrix printers.

On Computing Local Support Basis Representations of Cubic "Geometric" Splines, John Gregory, Brunel University, Uxbridge, U.K. (joint with Muhammad Sarfraz and Jianwei Zhou). Gregory first gave a review of cubic geometric splines such as ν-splines, weighted splines, weighted ν-splines, and β-splines in terms of the connection matrix for derivatives. The generalized (or weighted) ν-spline is the most general, and this can be represented in terms of double-knot B-splines. The Bézier vertices of the representation can be computed through a process of simply finding the intersection of certain lines.

Conditions for Regular B-Spline Curves and Surfaces, Nira Dyn, Tel Aviv University (joint with D. Levin and I. Yad-Shalom). Dyn defined a regular parametric spline as one that has a continuous unit tangent vector and no self intersections. She then showed the regularity condition is implied by the nonintersection of the convex hulls of certain subsets of control points, the sufficiency condition being slightly different for odd-and-even order splines. The extension to B-spline surfaces is not quite as nice, involving the nonintersection of cones of certain subsets of control vertices.

A G^1 Triangular Spline Surface of Arbitrary Topology, Charles Loop, University of Washington. Loop discussed the problem of constructing (closed) surfaces defined over an arbitrary triangulation. For geometric continuity of order one, the key problem is that of twist (cross partial derivative) values at the vertices. The compatibility equations for a vertex are somewhat messy. The equations to be satisfied form a linear system with the coefficient matrix involving first and second derivatives along triangle boundaries. Loop's strategy is to construct quartic boundary curves so the necessary twists will lie in the column space of the coefficient matrix for the system. The process does not always work, but Loop showed some nice examples of successful application of the ideas.

Pythagorean Hodographs, Rida T. Farouki, IBM Watson Research Center.

Hard Problems, Miriam Lucian, Boeing Commercial Airplane Company, Seattle, Washington. Lucian discussed some difficult problems that occur in industrial settings in the general categories of tolerances and consistency, data reduction, user requirements, limiting cases, documentation of algorithms, data exchange, and compatibility and consistency among CAD/CAM systems. She would welcome academic attention to some of the issues, and even though some of them may seem to be "unexciting" from an academic viewpoint, they do involve important problems that need to be solved.

Modeling with Trivariate Data, Bernd Hamann, Arizona State University. Hamann discussed the problems of modeling and visualizing three-dimensional data, citing many sources of such information, both gridded and irregularly spaced. His long-term goals are to be able to (1) extract the relevant features from the data, (2) find structure in the data when it exists, (3) model the data, and (4) visualize the data. Hamann's proposed techniques for modeling the data possibly involves data reduction and noise removal; estimating gradients, contouring, triangulating (or tetrahedralizing) data with optimization of the triangulation; local estimation of derivatives, generating a G^1 surface on the triangulation by a generalized

side-vertex method; and interrogating and displaying the data. Displays of information such as curvature are possible. Hamann is a student and noted that this was like a preliminary report on work in progress. His primary example came from a series of CAT scans of a human head, and involved some 45,000 triangles.

Transformation of Curve and Surface Representations, Michael Pratt, Cranfield Institute of Technology, Cranfield, U.K. The magnitude of the data transformation problem was emphasized by noting that BMW has 7 different CAD systems internally, with 38 more systems in use by contractors. Thus, there is a pressing need to transform data between systems. Transformation from a system using rationals to one that uses polynomials involves approximation, and even among systems that use polynomials, transformations are necessary if the system to be transformed to uses lower degree. Pratt discussed using constrained Chebyshev polynomials to lower the degree of curves (optimal if reducing degree by one, and suboptimally by successive application if by more than one). This work is the result of Lachance and Goult and has been mentioned previously (see *ESNIB* 90-04:26).

Convexity of Piecewise Polynomials over a Triangulation, Hartmut Prautsch, Rensselaer Polytechnic Institute, Troy, New York (moving to University of Karlsruhe). Prautsch developed a view of Bézier curves and surfaces that permits a unified way of looking at bases, degree elevation, uniform subdivisions, and the convex hull.

I. Parametric Free Curve and Surface Fitting, and II. Issues in Curve and Surface Design, David Ferguson, Boeing Computer Services, Seattle, Washington (joint with Tom Grandine). Ferguson discussed some problems that occur in a commercial manufacturing setting, and are perhaps not often enough considered by academicians. One particular example involved modeling a part (still in production) more than 20 years old (this points out the problem of parts life being longer than CAD systems life). The engineering data consisted of some 1,800 (scattered) measurements, poorly distributed and with inadequate boundary specification. Initial attempts to fit the data with a parametric bicubic spline resulted in poor parameterization and an unsatisfactory fit. Subsequent "tweaking" of the scheme gave an adequate representation. However, Ferguson would like to see a more automatic way of obtaining the data and the subsequent fit. Ferguson is an advocate of optimization to obtain surface approximations which preserve important properties (for example, convexity) but optimize on some desirable cost function, such as area (hence weight) of the part.

Curve-Mesh Fairing, Pangiotis Kaklis, Technical University of Berlin (joint with H. Nowacki and U. Unlauf). Kaklis is a naval architect and discussed the problem of mesh line fairing of data involving errors. He used bicubic splines with the assumption of a quadrilateral topology. The rectangular mesh curves must intersect, of course, and the data is smoothed using a combination of the usual spline functional and the *lack of fidelity* measure for the data. He assumed that the data may be in error in each variable, so a nonlinear programing problem results. Potential problems occur near the bow and stern since nearly triangular patches occur. An attempt to use Generalized Cross Validation (GCV) to choose smoothing parameters was reported on, but this seems to work poorly for small numbers of point (around 200) while it works well for around 900 points. Kaklis wants to look more at the stochastic side of the process and attempt to estimate covariance to determine some information about how good the fit may be.

Geometric Construction and Knot Insertion for Geometrically Continuous Spline Curves of Arbitrary Degree, Hans-Peter Seidel, University of Waterloo. Seidel briefly reviewed polar forms and blossoming. Then osculating flats, universal polynomials, and geometric spline curves led to universal splines. Then it is possible to compute Bézier points from control points, develop locally supported splines, perform knot insertion, and evaluate splines in a stable manner.

Algebra, Topology, and Combinatorial Algorithms (my title--Brun gave none), Jean Marc Brun, Coretech International, Les Ulis, France. Brun listed the contrasting important ideas in algebra and topology, given here in his pairings: best way to compute versus best way to avoid, elegance versus simplicity, accuracy versus exactness, robust schemes versus exact processes, convergence versus sorting, fast (computation) versus slow (growth of computation). Brun then discussed combinatorial algorithms and worst performance versus best performance and acceptable ways of speeding up algorithms. He noted that the best performance may be obtained through using tricks, but leads to programs that are not maintainable and thus should be avoided. He considered the problem of hidden line removal as a detailed example. The basic problem is one of line intersection, or rather, that of intersection of line segments. Computing possible intersections and then checking involves considerable useless computation. For more efficiency, check to see if both endpoints of a line segment are on opposite sides of the line before proceeding with the intersection. If they are, you can easily compute the parameter value of the intersection from the distance calculation necessary to determine the former. The apparent complexity is still the same, $O(N^2)$, but actual calculation time is quicker,

and may even behave almost like O(N logN) for the N of interest. Another point Brun pointed out is that it is important to monitor performance of various parts of an algorithm because as they are improved, the major portions of time are eventually used in unexpected places.

Approximate Conversion of Curves with Bézier Curves by Minimization Methods, Arie Jacobi, Hebrew University of Jerusalem (joint with Michel Bercovier). The use of finite-element type methods to approximate curves (possibly offsets of other curves) was proposed. A linear combination of the 2-norms of the difference between the given and approximate values, first derivatives, and second derivatives, was minimized. Jacobi determined the placement of the knots for the parametric cubic curves by analyzing the curvature profile for angular change as well as determining derivative discontinuities. This work is in progress. For the future, it is expected to treat reparameterization and to investigate the possibility of maintaining an orthogonality constraint between the approximated curve and the error vector between curves (the error is measured as the difference between values at identical parameter values), and further processing of offset curves for loop detection and elimination.

Closing Comments

This meeting was a mixture of reviews of present practice in the mathematics of computer-aided curve and surface design (the overview lectures and the presentations of industrial lecturers), new (and more mature) ways of looking at old ideas (polar forms and blossoming, and generalized ways of looking at rational curves and surfaces in B-spline or Bézier representation), and emerging ideas in approximating and otherwise dealing with 3- and higher- dimensional data in a way that brings out the salient features of the data. Almost certainly, the most exciting areas in the latter instance will be useful in the emerging and important (and, yes, currently fashionable) area of scientific visualization. While there is no doubt that not all of the problems in CAGD have been solved from the standpoint of making CAD systems user friendly, nearly "goof-proof," and easily usable by non-mathematical designers, I think major efforts in academic centers will be toward ideas useful in analyzing and visualizing scientific data. The beginning of such work can be noted in this report.

Finally, a historical note. On Wednesday afternoon, an excursion to the archaeological site Selinunte on the southern coast of Sicily was part of the organized activities. The ruins date from around 650 B.C. To my knowledge, all attendees were surprised to find that Pythagoras (perhaps the most widely known mathematician of all) played a prominent part in the early history of Selinunte. Pythagoras lived from around 570 to 472 B.C. In 540 B.C., he and Telemaco led the Agrigentines against Falaride (apparently giving up mathematics early in life). Then in 510 B.C., he took Selinunte by force, and became known as *the second tyrant of Selinunte*.

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PHYSICS

Transient Hollow Cathode Discharge Phenomena

by Marco S. Di Capua, the Liaison Scientist for Physics in the Office of Naval Research European Office. Dr. Di Capua is an experimental physicist on leave from the Lawrence Livermore National Laboratory of the University of California.

Introduction

The Transient Hollow Cathode Discharge Phenomena (THCD) program is one example of collaborations funded partially through the European Community (EC) SCIENCE program (see *ESNIB* 90-02:37). The SCIENCE THCD program involves researchers at Imperial College and University of Swansea, U.K., the University of Erlangen-Nuremberg, and the Karlsruhe Nuclear Research Center (KfK), Federal Republic of Germany (FRG). The subsequent collaboration of the Centre National de la Recherche Scientifique (CNRS) Laboratory of Dense Plasmas of the University of Paris and the Centre de Physique Atomique de Toulouse (CPAT) (attached to the Paul Sabatier University, Toulouse) are independently funded by the CNRS in France. The collaboration of the French in this project is a direct result of the flexible nature of the contract under the EC SCIENCE Plan.

The 1989 THCD workshop held in Paris, September 11-12, 1989, reviewed results of the collaboration originally funded by the Stimulation Action Program (1985-1988). The Imperial College started this cooperative effort in 1985 and was funded by a Twinning Contract in 1986. The workshop tried to look back at 3 years of research and establish research directions for the future.

This is the first workshop dedicated to workers engaged in experimental and theoretical studies of the transient phenomena in discharges with a hollow cathode geometry. The workshop covered aspects of pulsed hollow cathode discharges including ionization growth, discharge formation, generation of electron and ion beams, switching properties, and related physics.

Peter Choi, Imperial College, London, and Maurice Skowronek, Dense Plasma Laboratory, Pierre and Marie Curie University, Paris, cochaired the workshop. Jean Lalour, the scientific secretary, flawlessly executed the local arrangements in spite of the summer holiday and a short notice for the meeting.

In addition to the participants and would-be participants in the THCD program, the workshop, partly sponsored by Office Naval Research European Office (ONREUR), gathered researchers from:

- The CPAT, the Discharge Physics Laboratory at the Ecole Superieure d'Electricite, Gif sur Ivette, France
- Research Center of the Compagnie General de Electricite, Marcoussis, France
- Naval Research Laboratory, Washington, D.C.
- The University of Southern California (USC).

The meeting took place at the Pierre and Marie Curie University in the 7th District. This city center campus covers 300,000 m^2 at the edge of the Latin Quarter. The land was the site of the Paris wholesale wine market (Halles au Vin) that became a victim, in the mid-fifties, of urban congestion, new distribution methods, and a change in modes of transportation. The campus hosts 3,000 researchers and 2,000 technicians. The campus' 300 laboratories, which branch off into 20 km of hallways, include most of the science fields.

The THCD workshop is one example of the methods that the SCIENCE Plan uses to foster scientific cooperation. By supporting a high-level course within a member of the EC, the plan encourages participation from other EC members. Supplemental support for the THCD workshop from ONREUR contributed to fostering contacts with U.S. researchers.

THCD Devices

The THCD takes place in low-pressure gases, typically at pressures of 30 Pa (a fraction of a Torr), voltages between 1 and 400 kV, and anode-cathode gap distances of 1 to 5 cm. A cavity in the cathode communicates with the anode-cathode gap space through a hole in the cathode. The cathode cavity endows THCDs with peculiar properties:

- Quiescent DC glow discharge phase that draws a few μA

- Slow development of the predischarge that can last about $1\,\mu$s and whose evolution can be influenced by a variety of triggering modes

- Development of the hollow cathode (HC) that results in a very rapid increase of ionization (~ 1 .0E-08 s) in the gap and an exponential increase in the conductance

- Production of an intense electron beam that can be extracted at the anode

- Low resistance, high current discharge phase that exhibits Z-pinch like behavior. This discharge appears as super-dense ($n_e = 1.0E+15\ cm^{-3}$) glow that can carry $1.0E+04\ A\ cm^{-2}$ for μs-times without hot spots and arcing

- Decay of the plasma as current goes through zero.

Understanding of the breakdown mechanism of THCD is very primitive. The electric field distribution in the THCD geometry during the quiescent μA discharge phase is unknown. One conjecture is that the large E/p (and therefore a large α/p) resulting from field enhancement around the cathode hole favors an electron avalanche near the hole that starts with seed electrons (charge injection) delivered by the trigger. The field near the hole depletes the downstream electrons, thus enhancing the avalanche. The plasmas produced by the avalanche then propagate at $2.0\ m\ \mu s^{-1}$ into the cathode cavity and into the main anode-cathode gap. Ions that accelerate across the cathode sheath, stimulate further emission that sustains the discharge.

Research into THCD devices is motivated by their possible application as sources of electrons, sources of x rays, and repetitive fast switches. Exploitation, for repetitive switching, of the fast ionization rise and rapid quenching of the low-pressure discharge may result in switches with:

- Nanosecond jitter with reliable charge injection or creation of ionization in the cathode region

- 40 kV/gap operating voltage

- 4-40 kA peak conduction currents in a diffuse glow

- A few $1.0E+11\ A\ s^{-1}$ current rise

- Rapid quenching of the conducting plasma as the current passes through zero

- Low cathode erosion rate caused by field enhanced thermionic (Schottky) emission resulting in current densities of $1.0E+04\ A\ cm^{-2}$ at 0.3-0.4 eV cathode temperatures

- An extraordinary cathode where current densities are very high and ion beams, rather than a Joule-heated filament, provide the heating.

Such switches are useful because they conduct larger currents than thyratrons, do not require housekeeping power, and display larger di/dt than thyratrons. For repetitive applications in accelerator modulators, as well as space applications, these properties could be very important.

For triggering, charge injection into the cathode can be accomplished by a pulsed or DC corona discharge, a pulsed surface discharge within the cathode cavity, release of photoelectrons by an ultraviolet (UV) light source, or a pulsed ferroelectric.

Modeling of THCDs

J.P. Boeuf, CPAT, discussed some of the work he has pioneered in developing sophisticated models which aim at an accurate, self-consistent description of glow discharges. The most important feature of the models is that they couple, self-consistently, charged particle production (ionization rate) and transport with the electric field; i.e., the ion and electron kinetics and Poisson's equation. Boeuf's models so far have contributed to the understanding of the interaction of the cathode sheath and the charged-particle kinetics in DC cold cathode discharges. Such models can be useful to deal with complex cathode configurations such as hollow cathode laser electrodes, plasma display panels, plasma etching, and plasma deposition, as well as RF discharges (Boeuf, 1988, 1990, 1990a).

Boeuf provided a glimpse on the insight these self-consistent models provide by displaying preliminary results from a THCD simulation that demonstrates the penetration of the positive column in the cathode cavity, constriction of the plasma column near the hole in the cathode, very large electric fields on the cathode surface, and a very large electron density at the throat of the cathode. According to Choi, Boeuf's model incorporates a beam-bulk description that allows calculations in the high E/p regime where the local field approximation is no longer valid.

The next step in Boeuf's research is to incorporate the HC effect by modeling self-consistently thermionic and field emission at the cathode, and modeling self-consistently the ionization phenomena in the HC.

Boeuf emphasized the need for space and time resolved spectroscopic measurements of electric fields, as well as electron and ion densities in the HC region. These measurements would be a foundation to confirm the predictions of the model.

K. Mittag, KfK, presented the first results from a newly established calculation effort. Mittag's and Boeuf's calculations are similar except that in Mittag's, the Townsend coefficient governs electron multiplication. This coefficient folds in all the collision kinetics and cross sections. Therefore, it is accurate over a limited range of particle distribution functions.

Measurements of Plasma Properties in THCD

Experimental work on THCD has concentrated on their switching and other peculiar properties, rather than on detailed measurements of plasma properties that could be incorporated in a model of the discharge. This situation will change rapidly since empirical investigations are reaching the stage of diminishing returns and predictive numerical models require measurements of physical quantities.

G. Kirkman described the diagnostics used at USC to probe a laser-triggered THCD. The emphasis of Kirkman's presentation was on emission at the cathode that he suggested was caused by self-heating of the cathode by ions accelerated in the cathode sheath. Kirkman also measured electrical parameters of the discharge, as well as time resolved intensities of the $H\alpha$, $H\beta$, and $H\gamma$ lines. At 12 kA, the discharge is homogeneous with diffuse glow-like character. I was expecting Kirkman to discuss the spectroscopic measurements and his assessment of time-resolved electron densities, perhaps integrated over the line of sight. However, the only data available so far is an estimate of $n_e = 1.0E + 15$ e cm^{-3} and $T_e < 1$ eV.

J. Christiansen's, University of Erlangen/Nuremberg, research concentrates on a detailed investigation of the predischarge phase which is critical to reliable triggering of a long-life configuration for repetitive applications. His efforts, funded by BMFT, the West German Federal Ministry for Research and Technology, is aimed at the development of a repetitive switch for flash lamp pumped, high-power lasers for material processing.

Applications of THCD

Switching Applications. As discussed by G. Lins, Siemens Research Laboratories, Erlangen, the trade-off in THCD switches is between the hold-off voltage (which increases with decreasing pressure up to the Kirkpatrick limit), and the dwell time and jitter (that decreases with increasing pressure). Low-pressure operation has a further drawback of enhanced electrode erosion by ion impact at the cathode and runaway electron impact at the anode.

Lins discussed some cathode baffle geometries to lower jitter and raise the hold-off voltage. The physics of these baffles appears sufficiently complicated so convergence to a successful device will require a cycle of accurate measurements, predictive modeling, and technology implementation.

Christiansen also discussed life testing of a sealed ceramic THCD switch (Mo electrodes, D_2 gas fill, glow discharge trigger). The switch operated with a 32-kV, 25-kA drive from a 100-ns water-dielectric, pulse-forming line source, into a short circuit load providing a 90-percent current reversal within 10 cycles (about 1 s). The

switch failed after $8.0E + 06$ shots because of electrode erosion at the apertures. The switch may survive 10 times as many shots when operated with an energy-absorbing load.

Modeling could also be useful to determine the upper limit of reliable hold-off voltage at a given pressure and to determine the optimum baffle geometry to reduce the jitter.

Electrode erosion products weaken the voltage hold-off strength of the switch envelope. Meander geometry baffles that slow down the rate of deposition enhance the electric fields within the gap and lower the overall hold-off voltage. The choice of an appropriate geometry is another challenge that switch designers must face.

A presentation of M. Gundersen, USC, displayed a gamut of possible applications awaiting a successful optically triggered THCD, also known as backlit, or optically triggered thyratrons that:

- Could compete with ignitrons and thyratrons in applications that require a switch that is isolated from ground (no heater supply, photon triggering)
- Could replace switches in transformer-driven devices such as the SLAC modulators
- Could replace gaps in Marx generators for multi-module accelerators.

New Plasma Device Applications. The high-density uniform plasmas supported by high-emission cathodes arising in THCD could also find application in plasma-based devices such as:

- Plasma wake-field accelerators (7-cm long plasmas, $n_e = 3.0E + 14$ cm^{-3}) and beat-wave accelerators ($n_e = 1.0E + 17$ cm^{-3}) proposed at the University of California Los Angeles (UCLA), (Dawson, 1989)
- Active plasma lenses for particle focusing in cyclic accelerators (Autin, 1987).

X-ray Production. The THCD fed by fast energy storage sources such as charged coaxial cables or low-inductance capacitors emit highly localized, short duration bursts of x rays that provide information about energetic processes in the discharge plasmas. M. Skowronek, Pierre and Marie Curie University, determined that x-ray emission from a 1-J source with a pointed rod anode and a ring cathode arise in two bursts. The first burst is bremsstrahlung from the anode by electrons accelerated from the trigger plasma. The second burst, which arises when the main gap breaks down, comprises beam-target and beam-plasma x rays. At 45 kV, with 0.38 J stored, the discharge can produce 64 μJ of x rays into 4π (Skowronek, 1989). C. Wong, University of Malaya, Kuala Lumpur, Malaysia, using a larger system determined that x-ray emission takes place at the same time the derivative of the current shows a large drop associated with the pinch of the beam on axis. Finally, C. Schultheiss, KfK, identified

three x-ray source regions in THCD: one is bremsstrahlung from a self-pinched beam at the anode, a second is bremsstrahlung from the wall of the discharge channel, and the third and most intense one is from a 1-mm^3 volume of 9-keV hydrogen plasma at the exit of the hollow cathode.

Conclusions

At the moment, one of the attractions of THCD is that they are a very effective means for low-budget training of researchers in pulse power, plasma physics, and x-ray measurements. They can also be useful as point sources of x rays. Their most intriguing application is to repetitive switching, as previously discussed. This application awaits a better understanding of the ionization, conduction, and plasma dynamics of the discharge. Numerical models now coming on-line will speed up this understanding and will provide direction to device designers. Validation of the models demands some detailed surveys of the plasma properties in the discharge. Experiments are now coming on-line to allow these measurements.

Judging from the SCIENCE plan viewpoint, this meeting was a success. Scientists were brought together and found a common ground to launch the next research step.

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International Workshop on Low-Temperature Detectors

by Steven E. King, Deborah Van Vechten, and Gary W. Phillips. Drs. King and Phillips are nuclear physicists in the Radiation Detection Section; Dr. Van Vechten is a condensed matter physicist in the X-Ray Astronomy Branch at the Naval Research Laboratory, Washington, D.C.

Introduction

Advances in basic physics are often the result of the development of new measurement tools. This synergy motivated the Third International Workshop on Low-Temperature Detectors for Neutrinos and Dark Matter, September 20-23, 1989, at the Gran Sasso National Laboratory in L'Aquila, Italy. Identifying the *missing* and predominate mass of the universe (dark matter) has long been a principal motivation for the development of cryogenic detectors. However, many other problems provide exciting possible applications for cryogenic detector techniques--detection of low-energy solar neutrinos, measurement of the neutrino mass, development of cosmic x-ray telescopes, rad-hard detectors for accelerators (e.g., Superconducting Super Collider, Large Hadron Collider), and searches for axions, magnetic monopoles, and supersymmetric particles. The third annual workshop shifted the emphasis from ideas and plans to experimental results. The conference subjects were:

- Superheated, superconducting granules (SSG)
- Superconducting tunneling junctions (STJ)
- Bolometers and ballistic phonon detectors
- Electronics and other topics.

Professor E. Fiorini, University of Milan, Italy, organized the conference. The Gran Sasso Laboratory is a major new INFN facility with offices, shops, and conference rooms above ground. The laboratory has experimental areas within the Gran Sasso tunnel. With a minimum of 1,400 m of shielding rock, it is one of the world's best low background facilities. The conference included a tour of the facility where construction was underway on

1. GALLIX (the gallium low-energy solar neutrino experiment)

2. MACRO (a magnetic monopole detector)

3. LVD (a large volume detector for high-energy neutrino research from supernova).

Session highlights are discussed below: conference proceedings will be published during the next year. Direct inquiries about the proceedings to:

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Presentations

The speakers and their affiliation are identified in the following discussion.

Motivating Physics

The workshop began with three overview talks. These covered detector requirements in the fields of subnuclear physics, cosmic x rays, and dark-matter astryophysics. G. Stegman, Ohio State University, Columbus, Ohio, gave a concise review of the dark-matter problem. Looking at increasing length scales in the universe, the discrepancy grows between the mass associated with luminous objects and the mass necessary for Newtonian dynamics to explain the relative motion of objects. Indeed, an estimated 90 to 99 percent of the mass of the universe has not been identified. Extensive searches for nonluminous baryonic matter have failed. An alternative candidate for the missing mass is nonhadronic matter. The existence of hot nonhadronic dark matter (matter that decoupled from ordinary matter while still relativistic) could explain the large-scale structure of the universe, but not the small-scale lumpiness. A light neutrino is the best hot, dark-matter candidate. Candidates for cold dark matter include heavy neutrinos, super symmetric (SUSY) particles, axions and other, more exotic particles. However, cosmologies using cold, dark matter require an additional (arbitrary addition) condition to explain the early universe uniformity. Since all of the nonhadronic particles are weakly interacting with hadronic matter, their detection requires large detectors sensitive to very low-energy depositions. These particles can produce unique signatures for neutrinos or dark matter, and effectively discriminating against ordinary radiation and particle backgrounds.

R. Moessbauer, Technical University of Munich (TUM), Garching, Federal Republic of Germany (FRG), discussed the many neutrino questions. These questions include: what is the neutrino mass? how many flavors exist? is flavor conserved? and are neutrinos Dirac or Majorana particles? One proposed answer is detecting nuclei that recoil with typical energies of 1 to 1,000 eV from coherent neutrino scattering. To achieve this very low-energy, detection threshold will require cryogenic detectors. The scattering cross sections for the appropriate detector material may be up to 1,000 times larger than for existing neutrino detectors.

Finally, R. Giacconi, Space & Telescope Science Institute (NASA), Baltimore, Maryland, explained that x-ray telescopes provide a look at the early universe and high-energy processes. These processes include hot plasmas, the birth of star, and binary star systems. The next generation of satellites requires a moderate spatial resolution, high-efficiency imager with 10-eV energy resolution. Again, achieving this will require cryogenic detectors.

Superheated Superconducting Granules

During last year, significant progress has been made on SSG devices. Superconducting spheres (tens of microns in size, embedded in or attached to an insulating material) compose these devices. In a magnetic field, the superheated granules can undergo a fast-phase transition or *flip*. The granules may also change to the normal state upon the absorption of additional energy. The consequent change in magnetic flux is detected using a SQUID or pick-up coil readout. The effect is well demonstrated in a variety of soft, type I materials. Designing a suitable dark-matter detector requires efforts on reducing grain size, improving grain uniformity and low noise, fast readout electronics, studying the *avalanche effect*, and understanding the dynamic, nonequilibrium *flipping* process.

The most exciting SSG breakthrough (Turrel, University of British Columbia, Canada) was the production of ordered arrays of indium grains on mylar film using lithographic techniques. This work resulted in a much greater uniformity of grain size (< 10 percent variation in diameter) and corresponding uniformity in energy absorption response. A. Singsaas's (Max Planck, Munich, FRG) experimental and Perrin's (École Normale Superieure, Paris) theoretical work focused on understanding the basic *flipping* mechanism including nucleation. T. Ebisu, Kobe University, Japan, discussed the response of large single grains to alpha particles of variable energy and regular arrays of magnetically isolated grains. A. Drukier, Applied Research Corporation/University of South Carolina, and L. Gonzales-Mestres, Laboratoire d' Annecy le Vieux de Physique des Particules Annecy, France, presented strong, but not conclusive, evidence for the avalanche effect (in which multiple grains are flipped through the transfer of phonons between grains). The avalanche effect may prove an important solution in detecting the small signals produced by the small grains needed for a low-energy threshold detector. P. Espigat, College of France, Paris, France, raised a warning flag suggesting that large grains ($> 20 \mu$m) may switch into the intermediate state (in which only part of a grain volume has a phase change) rather than the normal state. Also,

the magnetic intergrain interactions may play a role in the avalanches.

Superconducting Tunneling Junctions

The Superconducting Tunneling Junctions (STJ) are devices composed of a sandwich of superconducting-insulating-superconducting layers. The STJ detectors measure the charge pulse resulting from tunneling across the insulating barrier of quasiparticles created in one of the superconducting layers by absorbing particles or radiation. The STJ detectors are appealing because the small superconducting energy gap (about 1 meV) should provide 30 times better energy resolution than semiconductor detectors. In addition, they should provide high spatial resolution as a result of their inherently small size while operating at reasonably accessible temperatures.

A conference highlight was H. Kraus' (TUM) presentation on x-ray detection using the quasiparticle trapping technique. Trapping is the funneling of quasiparticles from one superconducting layer to a second layer characterized by a smaller superconducting gap energy. The quasiparticles quickly thermalize in the smaller gap region and no longer have enough energy to return from whence they came. Use of Kraus' geometry may solve a major STJ design problem; the optimal designs for STJs and for radiation absorption do not coincide. Kraus built a large area particle absorber from tin and used four smaller gap Al tunnel junctions to read out the quasiparticle pulses. Lead leads (large gap) prevent diffusion of the quasiparticles away from the tunneling junctions. The device produced 60-eV energy resolution with a claimed spatial resolution of 5 μ within a 1,000 x 150-μ area. Further development is still needed, however, since losses in the tin requires junctions placed every 40 μ to achieve this resolution over the entire absorber area.

In another trapping phenomena study, Goldie, Oxford University, U.K., demonstrated that the proximity effect is crucial for quasiparticle transmission between superconductors by using laser excitation to study an indium absorber/aluminum STJ device. He also showed that a normal metal trap enhances the signal amplitude and reduces the trapping time.

A recurring workshop theme was the need for understanding the propagation of the burst of high-energy phonons produced when a particle or radiation is stopped in a solid. Some workshop results (Rothmund, Paul Scherer Institute, Villigen, Switzerland, and Peterrreins, TUM), have shown it is unclear whether the phonons propagate diffusively or ballistically and to what extent standard theories of phonon focusing, derived for low-energy phonons, apply.

Bolometers and Ballistic Phonon Detectors

Bolometers are low-temperature calorimeters with an attached or integral thermistor. Measuring the temperature rise in a bulk detects material radiation or particles.

The best x-ray resolution of any cryogenic detector is the 12-eV resolution obtained at 6 keV by McCammon, University of Wisconsin, using their silicon microbolometer. D. Camin and E. Fiorini, Milan, led a large group that made many advances including the design of large mass bolometers required for dark matter or neutrino detectors and the design of a low background experiment at Gran Sasso. They have achieved 25-keV energy resolution for d-particles in an energy range of 100 keV to 2 MeV with an 11-g rain-doped Ge bolometer. A bolometer for heavy ion detection (P. Egelhof, Mainz, FRG) was also under development.

Other phonon detectors use, like bolometers, a bulk absorber; however, the detectors measure the resultant energetic phonons when they strike the material's surface using STJs or so-called transition edge detectors. Transition edge detectors are superconducting strips that are current biased and held at a temperature at or slightly below the critical temperature. They measure either very small temperature increases using the large resistive change at the transition, or detect the energetic phonons by the transition of a local *hot spot* to the normal state. Th. Peterreins used 3 STJs on a 20 x 20 x 10-mm Si crystal to detect alpha particles. Seidel, TUM, reported on a bolometer using a transition edge thermometer with 50-nK temperature resolution. He reported a 1 percent energy resolution for 5.8-MeV alpha particles using a 280-gm Al_2O_3 absorber at 136 mK. B. Young, Stanford University, Stanford, California, discussed coincidence measurements made possible by multiple transition edge detectors fabricated on opposing faces of silicon wafers.

Other Topics

An important part of the detector development is developing suitable low-noise electronics for low-temperature detectors. A great effort to develop hybrid semiconductor-superconductor circuits for bolometric detectors is underway (G. Pessina, D. Camin, Milan). Kinder, TUM, proposed a novel phonon detector using the phonoatomic effect. Phonons produced in a bulk radiation absorber are capable of ejecting single atoms from a thin helium film, 1-nm thick, on radiation absorber surface. By placing a 70-K *hot plate* parallel to the film, atoms ejected from the film would be heated (accelerated) by collision with the hot plate. The repeated atomic collisions become a cascade. This cascade quickly evaporates the entire film resulting in a large induced phonon pulse in the bulk absorber which is easily detected. Such a device seems well suited as a trigger detector of low-energy events.

Conclusions

By comparing this meeting with previous quasi-annual meetings, one notes a stabilization in the number of ongoing research programs and the pursuit of detector

ideas. However, there were more reports on experimental results and on an increased understanding of the radiation/superconductor interface (as progress is made in each of the principal detector approaches). Although much progress has been made, it is clear that the full-scale application of low-temperature detectors to the detection of dark matter, neutrinos, cosmic x rays, or other particles is several years from fruition. Steady research is continuing toward these goals.

In contrast to the current American research in the field, the European laboratories appear more committed toward the long-term development of the field. They have developed large research teams or collaborations needed for a comprehensive, multidisciplinary detector development program. N. Booth will organize the next workshop; it will be in Great Britain in 1991.

The 1989 URSI International Symposium on Electromagnetic Theory

by Herbert Uberall, Department of Physics, the Catholic University of America, Washington, D.C.

Introduction

The International Union of Radio Science (URSI) holds triennial international symposia in different countries. Commission B (Fields and Waves) of URSI organized the 1989 Symposium on Electromagnetic Theory in cooperation with the URSI Swedish National Committee. The symposium was held at the Royal Institute of Technology (KTH), Stockholm, Sweden, August 14-17, 1989. The meeting's organizer and chairman was Professor Staffan Ström, KTH; the Technical Program Committee's chairman was Professor T.B.A. Senior, University of Michigan, Ann Arbor.

There were over 200 participants at the symposium. The U.S. delegation was about 50, the host country (Sweden) was about 35, and Japan about 15. Other large delegations came from the Federal Republic of Germany, France, the U.K., and the U.S.S.R. The latter delegation included the famed researcher, Peter Ya. Ufimtsev, Institute of Radio Engineering and Electronics, Moscow, one of the fathers of diffraction theory. The Physical Theory of Diffraction (PTD) is sometimes jokingly referred to as Peter's Theory of Diffraction. Delegates from 28 countries were represented at the symposium.

The symposium has issued a Proceedings book containing four-page abstracts of the contributed papers. (The invited talks were on Fields in Biological Media, and on Electromagnetic Transient Methods in Applied Geophysics.) This 650-page volume may be purchased, for $35, from Professor S. Ström, Department of Electromagnetic Theory, Royal Institute of Technology, S-10044 Stockholm, Sweden. Two sessions were scheduled in three parts: General Scattering and Diffraction; Inverse Scattering, and one in two parts, Random Media.

The topics were:
- Antennas (six sessions)
- Waveguides (five sessions)
- Media: random, isotropic, chiral (five sessions)
- Scattering theory (seven sessions)
- Transients (two sessions)
- Mathematical methods: finite differences, finite elements, integral equations, iteration techniques, moment methods, ray methods, uniform asymptotics, numerical methods (six sessions)
- Rough surfaces (one session)
- Periodic structures (one session)
- Nonlinear phenomena (one session).

This spans the entire spectrum of contemporary research in electromagnetic theory. My following detailed discussion of individual topics is biased by personal interest. As a consequence, this may cause the selection of topics discussed to be somewhat limited. This is no implication that the remaining papers were not worthy of discussion.

Scattering and Diffraction

This subject is one of the basic topics of electromagnetic theory established close to a century ago and marked by Mie, Sommerfeld, and Franz's works. T.B.A. Senior spoke on diffraction by a generalized impedance half plane. This presentation showed the pursuing of new developments in this area. In his work, he describes a

half-plane coated on both sides as characterized by a generalized boundary condition. Professor Senior uses approximate boundary conditions involving field derivatives higher than the first, as introduced by Karp and Karal (Karp, 1965), modeling the half-plane coating. Maliuzhinets' method (Maliuzhinets, 1958) treats the scattering of a plane incident wave by this half plane. This method is based on Sommerfeld's theory using the method of steepest descent. A complete solution is obtained in this way, in terms of Maliuzhinets half-plane functions. Using generalized boundary conditions, which accurately simulate the material properties of the surface coating, has made this possible.

John L. Volakis, University of Michigan, discussed how generalized impedance boundary conditions can further be used to model multilayer coatings. Backscattering for such a coating is shown reproducing accurately the traditional results where each plane is treated separately. However, boundary conditions are found to be invalid near discontinuities or terminations.

Moving on to scattering from a tube, J.D. Xu, Northwestern Polytechnical University, Xian Shaanxi, Peoples Republic of China, presented a method for analyzing this problem if the tube is curved (circular or S-shaped) with one endplate. The Geometrical Theory of Diffraction treats the diffraction from the rim of the aperture. The method of coupled modes (coupling the radiated field of the nth mode to the incident field) treats the effect of the field penetrating the tube. Numerical solutions predict exactly the experimental results this author obtained.

K. Muinonen, University of Helsinki, Finland, reported on an exact analytic solution for the scattering of electromagnetic waves from two interacting dipoles. This was motivated by the desire to explain from the known (Tsang, 1985) backscattering enhancement caused by constructive interference in multiple scattering, the observed light scattering features from planetary atmospheres and soil including a negative polarization. Dr. Muinonen's solution is an iterative solution of the coupled equations for the fields incident on each dipole, thus modeling the multiple scattering effects. The solution accurately describes the observed backscattering enhancement and negative polarization of the scattered return.

Inverse Scattering

Dr. Arthur K. Jordan, Naval Research Laboratory (NRL), Washington, D.C., and Professor Gerhard Kristensson, Lund University, Sweden, shared on this important subject. Dr. Jordan (coauthored with S. Lakshmanasamy) presented an inverse scattering theory for phase-conjugate reflection coefficients as applied to dielectric slab waveguides (consisting of a core and a cladding). The reflection coefficients, approximated by a three-pole expression, were used to reconstruct the refractive index profiles of the waveguide, from the phase behavior of the reflection coefficients. A phase change of π in a propagating mode upon internal reflection at the core-cladding boundary engenders a similar phase change in the reflection coefficient. The presence or absence of a propagating mode (bound state) can thus be determined; the design of a binary optical switch is then suggested in which one of two reflection coefficients supports a bound state.

Professor Kristensson's talk (jointly with Robert Krueger) dealt with transient scattering from spatially inhomogeneous, finite-length slabs. The inverse problem; i.e., the determination of the permittivity and conductivity profiles of the slab from a knowledge of finite time traces of scattered fields, is solved using (nonlinear) scattering operator techniques, and (linear) Green's function techniques. Obtaining the propagation kernel, one needs either transmission data corresponding to one round-trip, or reflection data from two round trips. An inversion algorithm corresponding to marching along a grid in travel-time space is developed for both techniques and successful reconstruction of assumed profiles in the slab is achieved.

Uniform Asymptotics

V.A. Cherepenin and M.G. Kurkin, Institute of Radio Engineering and Electronics, Moscow, U.S.S.R., treated the interaction of a relativistic electron beam with an electromagnetic field having a two-dimensional, cusp-like caustic region. This topic especially interested me since it had been briefly considered 20 years ago by my colleague at Catholic University, Professor Clyde L. Cowan, the neutrino codiscoverer. The purpose was devising a novel electron accelerator. Indeed, one deals with an inverse Cerenkov effect. Here an electron beam can be accelerated by resonantly taking energy out of an appropriately (cusp) shaped external field designed to resemble (incoming) Cerenkov radiation. Apparently, the design problem was solved in this exciting contribution, expecting it will soon lead to appropriate applications.

Professor Peter Ya. Ufimtsev presented a masterful (but, in the Proceedings, poorly documented) exposé on the history of the PTD he was instrumental in developing, as well as its recent progress on the high-frequency asymptotics of the edge waves involved. The first formulation of his new results was presented at the 1985 All-Union conference (Ufimtsev, 1985). Applications presented here referred to diffraction from straight and curved wedges. The diffracted field is represented as an integral over equivalent edge currents, evaluated at stationary points on the edge leading to ray asymptotics.

Boundary Value Problems with Transient Excitation

Douglas J. Taylor, NRL and Catholic University, Washington, D.C., jointly with the author, discussed the structure pattern of the complex natural frequencies of coated and lossy-dielectric spherical targets. The contribution also discussed the dispersive phase velocity curves of surface waves that cause resonances at these eigenfrequencies because of phase matching. Cases of dispersive dielectrics, described by dipolar relaxation (Debye-type dispersion) and the dependence of resonance frequencies on the relaxation parameters were also discussed. Later, the scattering of long transients from coated spheres was presented, based on previous work by William E. Howell (Howell, 1985 and 1990), NRL. The discussion showed that if the carrier frequency of the incident long, modulated pulse coincides with a resonance frequency of the target, a substantial distortion of the incident pulse shape occurs during scattering, in the form of a *double transient*: After an initial transient, the return pulse settles down to a forced quasi-steady state. At the termination of this state, a final transient appears which represents the decaying ringing of the resonance. The step-wise exponential decay of both transients can be explained by the multiple overlaps of circumferential wavetrains.

Chiral Media

The activities of Professors V.K. and V.V. Varadan, Pennsylvania State University, State College, Pennsylvania (Lahtakia, 1988, 1989), presently dominate this field. However, it has gained wider appeal; e.g., because of the French experiments (Priou), and an excellent overview (*Chiral media: New developments in an old field*) was presented by Werner S. Weiglhofer, University of Glasgow, Scotland. The field goes back to Aragot and Biot's discovery, in 1811, of optical activity. The now popular *chiral dielectrics* contain chiral objects (metal helices or parts of a helix) embedded in an achiral (polymer) host medium, leading to electromagnetic activity in the domain $\lambda/L = 20\text{-}100$. Maxwell's constitutive relations between D, B, E, and H are modified by introducing curls of the fields, multiplied by a chirality parameter β, leading to birefringence. Applications to chiral slabs and waveguides were presented, as well as to antennas in chiral media, and to chiral polymer design. *Chiral absorbers* (Priou) show a higher, resonant absorptivity than could be achieved with conventional radar absorbing materials.

Professor V.V. Varadan presented applications of chirality theory to multiple scattering in a random chiral material. Maxwell-Garnett and Bruggeman type models are used to treat the material by effective medium theory, and relationships between the macroscopic material parameters and microscopic polarizabilities are established

in a chiral medium. This field is, at the moment, in full development. Priou's (Priou) experiments gave a great boost to this field. The experiments demonstrated the large degree of absorptivity that can be achieved with chiral absorbers.

Anisotropic Media

Professor Piergiorgio Uslenghi, University of Illinois, Chicago, jointly with Bruno Andone, presented a general theory of multilayered anisotropic structures. This theory determines reflection and transmission coefficients for an obliquely incident plane wave. A Finnish group developed an exact image theory for uniaxially anisotropic dielectric halfspaces. Ismo V. Lindell, Helsinki University of Technology, Finland, reported this theory. This was applied to sea-ice containing spherical air bubbles as well as needle-shaped, parallel brine pockets, the latter causing anisotropy. R. Petit, Laboratory of Electromagnetic Optics, Centre National de la Recherche Scientifique, Marseilles, France, jointly with M. Cadilhac and G. Tayeb, dealt with the electromagnetic theory of anisotropic gratings (gratings ruled on an anisotropic material), as a generalization of their gratings theory (Petit, 1980).

Conclusions

The meeting presented an overview of the latest status of international research on electromagnetic theory, and provided valuable information to the delegates. The above discussion gives some highlights most interesting to me. The social highlight was a reception at the Stockholm City Hall in the rooms where the annual Nobel award presentations take place.

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PSYCHOLOGY

International Symposium on Neural Networks for Sensory and Motor Systems

by Dr. Joel L. Davis, Program Manager, Biological Intelligence, Office of Naval Research, Arlington, Virginia

Introduction

The Swissotel Rheinpark in Neuss (across the Rhine River from Dusseldorf) provided the setting for an International Symposium on Neural Networks for Sensory and Motor Systems. The conference took place on March 19-21, 1990, and was cosponsored by several American (including the Office of Naval Research [ONR]) and European Public Institutions. Professor Rolf Eckmiller of the Heinrich-Heine-University in Dusseldorf organized the conference. The program committee included representatives from France, the U.K., and the U.S.

The committee's stated goals were fourfold:

1. Review the most recent developments in the field of neural network simulators (both hardware and software)

2. Summarize the current knowledge in brain research on the sensory and motor systems neural control

3. Provide a description of new technical sensory and motor systems under control of artificial neural networks

4. Discuss the prospects of commercial neural network applications, in the near future.

Sixty leading scientists (about 50 percent from the U.S. and 50 percent from Europe, Japan, Canada, and Israel) were invited to give oral and poster presentations. At the time of the symposium, the invited participants delivered a camera-ready manuscript. A panel discussion, addressing the prospects of neural network applications, included representatives from various entities. These entities were IBM, National Science Foundation, ONR, European Strategic Programme for Research and Development in Information Technologies (ESPRIT), Basic Research in Adaptive Intelligence and Neurocomputing (BRAIN), Deutsche Forschungemeinschaft (DFG), and the state of Rhine-Westfalia, who discussed research funds availability and training programs for neural network research. I briefly present some symposium highlights (from my perspective). The interested reader will remember that a complete contributions collection will be available in July.

Neural Network Simulators

Dan Hammerstrom, Oregon Graduate Center, Beaverton, discussed an analysis and the very-large scale integration (VLSI) implementation of self-organizing networks. He stressed the importance in designing VLSI networks of understanding what the system computes. He is currently working on an implementation of the Lynch-Granger pyriform cortex model. In this more or less direct transition from biology, Hammerstrom stressed the problems that physical systems have in duplicating the *connection-rich* and three-dimensional geometry of biological systems. Hammerstrom prefers (for many reasons) a network containing nodes implementing a Hebbian algorithm for learning, rather than the more common supervised back propagation model.

Professor J.G. Taylor, King's College, London, proposed a neural processing model which is able to incorporate neurophysiological detail, including effects associated with the mechanics of post-synaptic summation, cell surface geometry, and axo-axonal interactions. The model is capable of hardware realization as a probabilistic random access memory. The model is built on Taylor's previous work. This newer version, by operating on much shorter time scales (of the lifetime order of a quantum of neurotransmitter in the synaptic cleft, o.1 msec) allows a retrieval of more information from the simulated spike train. The mathematical framework for the model is like that of an extended Markov process involving the firing histories of the N neurons. The extended neural network may be particularly applicable in situations where timing constraints are of special importance (such as auditory cortex). The network is also useful where firing thresholds are high, as in the case for granule and pyramidal cells in hippocampus.

Dr. Donald C. Wunsch, Boeing, Seattle, described an interesting application of biological neural systems to a feature recognition problem. Hypercolumn architectures are known to exist in the brain and have several valuable characteristics for processing image data. For example, they can be tuned to be maximally sensitive to various contrast levels of an intensity gradient. Their processing power can be extended further by considering the output of several differently tuned hypercolumns examining the same image. In fact, their powers often easily exceed the requirements for a given application. Dr. Wunsch applied hypercolumn architectures for preprocessing of radiographic weld image data determining regions of strong spatial intensity gradients. Dr. Wunsch has obtained a manageable proportion of false positives while eliminating any false negatives in this feature recognition problem.

Biological Sensory and Motor Systems

Professor Rolf Eckmiller, Heinrich-Heine-University, Dusseldorf, described his work on neural network topologies of the cerebellar cortex. One topology was used as a schematic circuit plan of the oculomotor pursuit system in primates. The plan emphasized several concepts in central nervous system information processing: brain regions are reciprocally interconnected and, therefore, do not allow a clear, logical separation of various sensory localization and motor functions; fault tolerance is probabilistically based on neural plasticity. This last capability gives neural systems the ability to adjust topology to new and changing tasks. This capability also takes over the function, to some limited extent, of another, damaged brain region.

Dr. Markus Miksa, University of Marburg, Federal Republic of Germany (FRG), presented an interesting new development tool for neural network simulations on transputers. Miksa's Artificial Neural Network Editor (ANNE) supports the object-oriented development of any interactive neural network simulation based on any size transputer networks. The data structures correspond to objects that may be spread over the whole transputer network in any way that are addressed by specific messages. This architecture allows development and programs test on a standard personal computer. Later, they are simply downloaded and run on the transputer hardware. Miksa's ANNE offers libraries for menu-driven graphical user interfaces, and possibly to generate arbitrarily connected neural networks. Dr. Miksa's ultimate goal, in this simulation development system, is reducing the time needed to construct new neural network applications.

Dr. Stefan Prange, Technical University of Berlin, presented an electronic neuron model based on work at the Institutes for Electronics and Bionics. The circuit contains one neuron with eight synapses and has the following features: a synapse building block widens an incoming rectangular pulse into a triangle. The descending flank slope can be regulated by an external voltage. The positive (or negative) weighing is adjusted by a second external voltage. These preprocessed signals are summed and put in a voltage-to-frequency-converter with a linearized threshold and saturation characteristics. The frequency range is adjustable.

In contrast to many existing neuron models, Prange's integrated circuit imitates the potentials at the membrane of a biological nerve cell more accurately. Currently, the simulation of dynamic neural networks on digital computers requires computation time. Realtime processing is usually achieved by the connection of several processors. Using this chip, the realistic emulation of small neural networks with up to 100 neurons is possible, making this type of research easier.

Professor Edmund Rolls, Oxford, U.K., discussed ways that information is represented, processed, and stored in neuronal networks in the hippocampus and cerebral cortex of primates. This is shown by the connections, synaptic modification rules, and neuronal activity recorded in these regions. Rolls elegantly showed how an analysis of synaptic modification and anatomy provide the basis for a computational cerebellum theory. This then can be understood at a systems level based on its inputs and outputs and the responses of single neurons found within it.

Professor Rolls suggested cortical-hippocampal (or limbic) interactions be modified by two sets of back projections. The first set was anatomically and neurophysiologically defined projecting to the apical dendrites of the cells in the surface sensory cortex layers. The backprojections second set ran from the first set of dendrites to dendrites of adjacent pyramidal cells. Thus, Rolls suggested that the well-known Parallel Distributed Processing models of Rumelhart, Hinton, and others might be adapted to biological reality with the addition of a second hidden layer. Rolls suggested that the back projection synapses were modifiable and used a glutaminergic (NMDA) receptor system. They could also be useful for information storage, recall, and attentional processes in biological systems.

Research Funds for Neural Network Research

A most interesting session was the first symposium bringing together representatives from various European and U.S. funding agencies to describe their neural network programs. Representatives from BRAIN, ESPRIT, and European Science Foundation attended from Brussels. The FRG was represented by officials from the Bundesministerium für Forschung und Technologie and

the DFG who helped support this meeting. Representatives from Defense Advanced Research Projects Agency, NASA, and ONR were also present, as was an unofficial representative of the Japanese Human Frontiers Program (K. Fukushima, Osaka). Application procedures, multi-national projects, and science-technology cooperation were all discussed. The European representatives all predicted increased funding levels for neural network research in the 1990s. In fact, several U.S. scientists queried the panel about European support for basic research in the U.S. The replies were somewhat ambiguous, but left the door open for multinational proposals.

At the close of the meeting, Professor Taylor (London) announced the formation of a European Neural Network Society. The society will have a seven-person board of directors with representatives from the U.K., Finland, FRG, Spain, Portugal, and Italy. Meetings are

scheduled for: Helsinki, 1991; London, 1992; and Italy, 1993. In addition, other neural network meetings are scheduled this fall: Paris, June; Prague, September; Nimes, November. These meetings show an intensive European interest in this field.

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SOLID-STATE PHYSICS

Sixth International Winter School on New Developments in Solid-State Physics

by Dean L. Mitchell, the Liaison Scientist for Solid-State Physics in Europe and the Middle East for the Office of Naval Research European Office

Introduction

On February 19-23, 1990, the Sixth International Winter School, organized by the Solid-State Division of the Austrian Physical Society and partially supported by the Office of Naval Research, Arlington, Virginia, was held in Mauterndorf, Austria. The first winter school in the series was held in an elementary school near Mauterndorf in 1980. Later winter schools were held at the regional castle located in Mauterndorf, Austria. The popularity of the event is because of both the topicality of the themes selected and the selection of the locale in prime ski country. In the heart of the Austrian Alps, Mauterndorf is located about 60 miles south of Salzburg and 120 miles southwest of Munich. At the same time, the Mauterndorf winter school is popular among academics since it exposes advanced graduate students and postdoctoral researchers to topics of current interest in an atmosphere that stimulates casual scientific interactions.

Presentation Summaries

"Localization and Confinement of Electrons in Semiconductors" was the topic for the 1990 winter school. The attendance of about 200 was comprised of "students" and advanced research investigators. Participants from the U.S., Russia, and Japan included:

- Kash and Worlock - Bellcore, Red Bank, New Jersey

- Awschalom, Heiblum, and Mendez - IBM Laboratories, Yorktown Heights, New York

- Eisenstein - ATT Bell Laboratories, Murray Hill, New York

- Reed - Texas Instruments, Arlington

- Ferry - Arizona State University, Tempe

- Wei - Princeton University, Princeton, New Jersey

- Sakaki and Katsumoto - University of Tokyo

- Pankratov - Lebedev Institute, Moscow

- Shikin and Khmielnitzski - Institute of Solid-State Physics, Chernogolovka, U.S.S.R.

The main theme of the presentations involved various aspects of the physics of zero-, one-, and two-dimensional (0-D, 1-D, and 2-D) electron gases as constrained by device structures fabricated with dimensions in the submicron range; i.e., thousands of nanometers. Techniques are available now for fabricating device structures in the range of 50-500 nm with electron mobilities, exceeding 10^7 cm^2/volt-sec at low temperatures. In this regime, a wide range of interesting quantum phenomena become amenable to experimental investigation including tunneling phenomena in quantum-coupled devices, hot-electron and ballistic transport in 2-D gas structures with 0-D or 1-D constrictions, and quantum interference phenomena in quantum-dot or quantum-line arrays.

The importance of quantum interference effects in quantum-dot and quantum-line devices is evidenced by the ubiquitous appearance of universal conductance fluctuations and Aharonov-Bohm oscillations in the transport properties of such devices. Research involving quantum-coupled device structures is an area of particularly strong activity in Europe with leading experimental groups in Austria, the Netherlands, Federal Republic of Germany (FRG), and the U.K.

Various names are used to define this emerging subfield of science and technology. Terms such as "submicron devices" and "microstructure devices" are disappearing from use with newer terms such as "nanoscale devices" and "mesoscopic devices" replacing them. The term nanoscale derives from the use of nanometers, or 10 Angstroms, as the natural unit for device dimensions rather than micrometers as the length scale used to define microelectronics.

D.E. Khmielnitzski, Institute of Solid-State Physics, Chernogolovka, provided a scientifically based definition of mesoscopic systems. He described such systems in terms of the relative length scales for individual device structures in relation to other physical lengths of the system such as the magnetic length, the temperature-dependent diffusion length, or the mean-free-path for inelastic scattering. For unclear reasons, he chose the temperature-dependent diffusion length as the relevant parameter for defining mesoscopic behavior; i.e., for sample or device sizes smaller than the diffusion length, the unique distribution of defects or impurities in each device would lead to unique transport properties. Only for device dimensions, large compared with this dimension, would the devices become uniform with operational parameters characteristic of the average electronic properties of the active electronic materials in the device.

Khmielnitzski developed a theoretical base for describing the temperature- and frequency-dependent transport coefficients for mesoscopic bridges. He was able to show that the frequency dependence for the transport coefficients of such nanobridges could serve as a "fingerprint" of the defect distribution in the same sense that the temperature dependence of the conductance fluctuations provide such a "fingerprint." He also derived other features of the linear and nonlinear responses of mesoscopic devices such as rectification and harmonic generation.

The Dutch group, headed by B. van Wees, Delft University, continued with their own particular phenomenology for a real-space description of the quantum mechanical electronic trajectories and electronic states in low-dimensional devices. L.P. Kouwenhoven developed this phenomenology by tracing the evolution of the miniband structure (as measured by the transport in periodic arrays of 0-D constrictions) from simple interference patterns for ballistic transport in weakly coupled periodic arrays of 0-D to fully developed minibands with well-defined energy gaps for more complex periodic arrays of quantum dots or constrictions. Kouwenhoven was able to track the evolution measured experimentally with a parallel theoretical description based on the Landauer-Büttiker transport formalism.

M. Heiblum, IBM, discussed ballistic transport in single devices. He demonstrated the successful operation of several "electron-optical" devices based on the analogue between the dependence of electron trajectories to potential energy variations and the dependence of optical trajectories on index of refraction variations. The 2-D electron-optics devices were fabricated with various configurations of source, lens, and collector on structures with an active layer of high-mobility 2-D electrons at low temperatures. Mono-energetic hot electrons can be launched in the 2-D layer from a 0-D emitter using the proper bias. Variously shaped gate electrodes serve as lenses and collectors. Heiblum demonstrated the feasibility of steering electrons in the 2-D layer by bias control similar to case for electron optics in 3-D using vacuum trajectories.

Quantum transport in 0-D quantum dots and 1-D quantum wires was the main topic at the winter school in number of papers and laboratories represented. J. Kotthaus, formerly of Hamburg, now at the University of Munich, has extended his optical and transport studies of 1-D interacting arrays to the study of arrays of quantum dots or boxes. He prepared the arrays on epitaxial InSb, epitaxial Si, and GaAs heterojunction active 2-D layers using holographic lithography. He used field-effect tuning to vary the dimensions of the 1-D widths and 0-D diameters. Using farinfrared spectroscopy, he provided information on dot dimensions and average number of elections per dot.

Kotthaus observed the transition from classical to quantum confinement most clearly in metal oxide semiconductor (MOS) devices using silicon substrates. Dot sizes of 300 nm and electron concentrations of 20 per dot were attained. The strongest confinement effects, however, were deduced for InSb where 80-nm dot diameters

led to 10-meV level splittings. The double-gate structure for devices on GaAs permitted separate tuning of the dot sizes and electron concentrations. Kotthaus also observed novel features in the infrared spectra because of quantum-coupling effects in these devices.

The integral and fractional Quantum Hall Effects (QHE) continued to draw active interest from both theorists and experimentalists. New results from the theory group at the Physikalisch-Technische Bundanstalt at Braunschweig considerably clarifies the role of localization on the temperature and frequency dependence of the step-widths for the integral QHE. The scaling properties for the decay length for the single-particle Green's function modulus were investigated for the case of high magnetic fields and zero temperatures. A version of the numerical finite-size scaling method was used which includes a quantitative statistical procedure for the data evaluation. The scaling parameter diverges in the center of the Landau levels with a critical exponent $\nu = 2.34$. The scaling parameter is identified with the localization length for the infinite system. The low-frequency ac conductivity was calculated in various regimes and from this, a vanishing dc conductivity was inferred. The results of the calculations appear to agree quite well with recent experimental results for the temperature and frequency dependence of the step-widths for the integral QHE.

The increased interest and activity in exploring the physics of nanoscale devices is mainly because of the recent improvements in Molecular-Beam-Epitaxial (MBE) and Metallo-Organic-Chemical-Vapor-Deposition (MOCVD) techniques for preparing high-quality epitaxial semiconductor films and heterostructures with accurately controlled impurity profiles. The improvements in materials, combined with improved lithographic techniques for microfabrication, now make it possible to fabricate complex device structures with features defined on the scale of 10-100 nm. Also, new classes of high-quality semiconductors, amenable heterojunction formation, and 2-D device fabrication are becoming available. These include: silicon, germanium, and their alloys; III-V compounds, including In/Ga:As/P and InSb; II-VI compounds such as Zn/Mn:Te/Te; and, IV-VI compounds such as Pb/Sn:Se/TE. The electronic behavior of such devices can be described, in many cases, by simple one-electron theories so that measurements on such devices provide examples of elementary quantum mechanics as presented in beginning texts. The simplicity of treating individual electron trajectories makes it possible to explore experimentally the complexity introduced by electron-interference, quantum-coupling effects, and the statistical effects of random scattering centers by suitable design of device configurations. The results to date hold promise of a rich phenomenology with potential for radical new device technologies.

Comments

Several groups in the U.S. and Japan are investigating the physics and device implications of nanoscale devices and mesoscopic science. The European groups, however, have had a major impact on this new field. I believe this is because of both the numbers of groups involved and the diversity of their approach. Also, traditional European barriers against collaboration across laboratory or national boundaries have crumbled. Groups with the best experimental techniques, say at Munich or Delft, have access to the best sample available, say from Phillips/Redhill or MPI/Stuttgart. In this regard, U.S. laboratories are lagging somewhat in making prime samples more widely available. This mode of research enterprise is increasing and must be encouraged.

Fun Time

The "Mauterndorf International Invitational Ski Race," held on Friday, was the major event of the week. There were 105 entries in this sixth running of the event. Kathy Kash, Bellcore, received a special award for finishing the course in 1:49 minutes. The event culminated her first week on the slopes. John Worlock, Bellcore, also received an award for finishing next-to-last in the senior category. As his prize, he delivered the after dinner remarks at the award banquet on Friday evening. The senior age threshold for this event was determined by the organizers so that they and their friends would be included, but able young skiers would be excluded. The age threshold for seniors has advanced by 2 years with each running of this event. Not by coincidence, the event is held biennially.

Kash helped her team, the "Supposed to be Winners," to a 16th place finish, one ahead of the "Former Communist Countries" team. The American team (Dave Ferry, Bruce McCombe, John Worlock, and Mark Reed) was disqualified when Reed missed a gate and crossed the finish line from the side.

Successful Tests on the
HELIOS Superconducting Synchrotron X-Ray Source

by Marco S. Di Capua

According to a recent report (Copper, 1990), Oxford Instruments, Oxford, U.K., announced on July 16, 1990, that tests on HELIOS (Di Capua, 1990), the superconducting synchrotron x-ray source, have been successful and HELIOS will be shipped to its first customer, the IBM East Fishkill Facility, Hopewell Junction, New York, in the fourth quarter of 1990. The London Financial Times reports (Skapinker, 1990) that IBM may use HELIOS in the manufacture of the 64 megabit, dynamic random access memory (D-Ram) chip (Cross, 1990) that should come into production in the mid-1990's. This new development places Oxford Instruments, which is a major manufacturer of superconducting magnets, as a leader in the technology of sources for x-ray lithography.

Tests began 2 months ago and improvements will continue for another 2 months to bring HELIOS up to its full 200-mA, 700-MeV beam specification. M. Wilson, the project leader at Oxford Instruments, will reveal details about the source at the International Microcircuit Engineering Conference in Chiba (Tokyo), Japan (July 16-20, 1990).

The road for Oxford Instruments, however, has not been an easy one, Oxford Instruments has been developing HELIOS since 1984 at a total cost of £14 million. In 1986, IBM is believed to have contributed £9 million and the U.K. Department of Trade and Industry provided another £1 million. Oxford Instruments had to provide about £4 million over the past 3 years to make up for the delays and cost over-runs of the project.

The biggest challenges for the project have been the small size of HELIOS, and its capability to sustain a large enough beam current (and hence x-ray output) between recharging.

According to Cooper's report, the breakthrough comes at a time when the COSY project in the Federal Republic of Germany may be still encountering problems as it reaches the final stage. The status of the Japanese synchrotron x-ray projects is still unclear. According to a January 1990 report (Cross, 1990), Nippon Telegraph and Telephone claimed last summer to have developed the world's smallest synchrotron. According to the same report, the SORTEC consortium of 13 Japanese electronic companies also claimed a record a few months later. Finally, at the end of December, Sumitomo Heavy Industries announced the 1-m diameter SOR machine that they expect to sell in 1991 at a price of 2.5 billion yen. However, Cooper (1990) reports that the Japanese are still encountering problems.

Oxford Instruments expects to have other customers for the source that will sell for approximately £15 million. One customer for this new x-ray lithography technology could be a new research center in Itzehoe (State of Schleswig-Holstein) that is partially funded by JESSI, the Joint European Submicron Silicon Initiative.

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NEWS, NOTES, AND ABSTRACTS

Office of Naval Research Needs Overseas Liaison Ocean Sciences Scientists in Tokyo and London

The Office of Naval Research (ONR) is soliciting letters of interest and résumés from qualified candidates to fill liaison scientist positions in its Tokyo and London offices. Candidates must be research scientists or research engineers currently, possess a Ph.D or equivalent experience in the ocean sciences, and be U.S. citizens. In general, ONR prefers candidates from the academic or government sectors. In addition, ONR prefers that candidates know about Navy and Department of Defense research and development (R&D) activities, have relevant established foreign contacts, have stature in the international R&D community, and demonstrate ability to write clearly and concisely.

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The U.K. Plans to Shift Research Overheads to Councils

by Dean L. Mitchell

The moves to rationalize the funding of university-based research in the U.K. continue with the development of plans to shift responsibility for overhead costs from the Universities Funding Council (UFC) to the research councils. Under the present system, the five research councils provide about £250 million in overhead costs for projects they support, but the UFC pays for staff salaries and existing facilities through block grants to the universities.

If the shift takes place, then £70 million per year will be transferred from the UFC to the budgets of the research councils. Thereafter, each grant application will require detailed cost figures for overheads such as equipment maintenance and computing. A percentage add-on will be provided for libraries, telephones, etc. No decision has been made about whether such costs as heating, lighting, and building expenses will be included in the new accounting scheme. These costs could continue to be funded as part of the universities' general expenses.

The overheads amount to a significant fraction of the total research funding for the five research councils who's budgets will total £880 million in fiscal year 1990-1991. The Science and Engineering Research Council (SERC),

the Medical Research Council (MRC), and the Natural Environment Research Council (NERC) will receive the largest share of the funds with allocations of £439 million, £186 million, and £135 million, respectively. There is concern that privately supported research will suffer since their overhead costs in the past have been borne by the UFC block grant. This will primarily affect medical research. There is also concern that young or unproven researchers will suffer since they no longer will be able to carry out research without a grant from one of the research councils. In this regard, the U.K. appears to be adopting the worst features of both the U.K.'s and U.S.'s rules and procedures for the support of university-based research.

The move to implement the new overhead rules appears to be close to adoption. Several physics departments that I visited were making plans, which would establish their base under the new allocations. Two of these departments will apparently fare quite differently under the new rules. The department that is in a relatively strong research university will fare quite well. The other, a teaching university with only a few strong research groups, will lose. This will likely further exacerbate the problems of smaller departments that already have taken their lumps from the Edwards Report on the future of university physics, which recommended that research funds be concentrated in the largest departments.

Nonlinear Systems

by David Feit

Research activity on nonlinear systems has mushroomed worldwide over the last two to three decades. As a result of this interest, the U.K. Science and Engineering Research Council (SERC) in 1985 set up a Nonlinear Systems Initiative through its Mathematics Committee. Other organizations, including NATO and the European Science Foundation, fund special programs and established centers dedicated to research in the areas of nonlinear systems.

I recently received a very handsome brochure from Professor David Crighton, Cambridge University; it describes some of the U.K. activities in this field. Crighton is now chairperson of the Nonlinear Systems Panel that produced this brochure entitled "The Remarkable World of Nonlinear Systems."

The brochure presents, in nonmathematical terms, an introductory discussion of nonlinear dynamical systems. Dynamical systems are mathematical models of processes, either natural or technological, that evolve in time. The nonlinearities come about because the governing interactions relate to products of the states, and not the states themselves as in linear processes.

Linear analysis is the basis for much of our past progress in the study of natural or technological phenomena.

I would venture to guess that many active researchers and scientists have had little or no formal training in the solution of nonlinear problems. This situation, I believe, is changing. Now, many of our colleges and universities, not only promote research in these areas, but also offer courses. Although I am only an observer to this field, my impression is that, in contrast, Soviet scientists have a long-standing tradition of excellence in the field of nonlinear analysis. Some colleagues who work in the area of nonlinear acoustics have compared meetings in the Soviet Union on the topic with many participants while comparable western meetings attract relatively few.

A surprising type of behavior that arises in nonlinear systems and receives much attention, even in the public media, is deterministic chaos. Such behavior is characterized by irregular and unpredictable fluctuations that arise in fairly simple nonlinear systems. In the usual circumstances one would expect that the future of the system is completely determined by the present state. What produces the unpredictability is the finiteness of the accuracy by which the present state must be specified.

The other phenomena discussed in the brochure are bifurcation, where small changes in a system produce unduly large effects. The mechanics applications of this are buckling of engineering structures, and the onset of large vibrations. Symmetry-breaking is another surprising aspect of nonlinear dynamics. A spherical shell when acted on by an increasingly large uniform external pressure is eventually forced into a buckled shape which violates spherical symmetry. The last surprising feature discussed is the emergence of large-scale order or the formation of recognizable patterns in systems displaying fine-scale chaos. The theory of nonlinear systems provides the unifying basis for understanding this phenomenon. The brochure gives examples of studies now pursued in the U.K., many of which SERC funds.

Through this document, SERC is seeking to publicize and encourage research initiatives in nonlinear systems. Professor Crighton chairs a panel that assesses proposals in this area. Although most of the panel members are British, two experts are from outside the U.K. Information on the initiative and further copies of the brochure can be obtained from: Science and Engineering Research Council, Polaris House, North Star Avenue, Swindon SN2 1ET, U.K.

Structural Acoustics at the Royal Aerospace Establishment

by David Feit

Introduction

The Royal Aerospace Establishment (RAE) at Farnborough, U.K., is the premier research establishment supporting aeronautical and space research in the U.K.

Two representatives, Drs. J. Copley and K. Heron, gave a joint presentation at the Mechanical Engineering Colloquia Series of Cambridge University's Engineering Department on March 15, 1990. The subject of their talk was "Structural Acoustics in Aerospace." Dr. Copley is currently head of the Noise and Vibration Section in the Helicopter and Dynamics Division of RAE. At the same time, K. Heron is one of a group of six investigators in that branch. Dr. Copley is moving on to a new position at the Ministry of Defense in London in late spring 1990.

Aerospace Applications of Structural Acoustics

J. Copley began the seminar with a discussion of what structural acoustics is in the context of aerospace applications. Within this discipline, he includes the study of pressure-induced vibrations on aerospace structures. He also includes acoustical transmission and radiation through and by such structures. They consider the following types of forcing: broadband excitation caused, for example, by weak shock oscillations or vortex flows, or narrow band excitations generated by rotating mechanisms; e.g., propellers, the periodic excitation caused by the meshing of gears.

As they would expect, the types of excitation that are involved are usually small enough in magnitude that linear theories of acoustics and vibrations are considered adequate. In transmission problems, they use the usual flexural vibration theories of panels or cylindrical structures. This accounts, when necessary, for the anisotropy or sandwich nature of the structure.

For a fuselage transmission application, the model used is a reinforced outer skin, strengthened by stringers and ribs combined with a sandwich structure. These components make up the interior trim of the cabin. The difficulties of the problem arise primarily from the complexity of the structures, not so much from the interaction of the fluid and the structure. This situation is somewhat akin to underwater structural acoustics problems. Although the fluid structure interaction is more significant (because of the much higher density of water compared to air), the major analysis problem still comes from the hull constructional complexity and the compatibility forces generated at the junctions between different components.

In aerospace applications, the vibration level predictions are important for problems related to structural fatigue where the structure's integrity may be compromised, and the sensitive avionics equipment fails. Of course, the acoustical noise environment bears significantly on crew performance as well as on passenger comfort. During this discussion, Dr. Copley remarked parenthetically that the U.K. has successfully used active control to mitigate internal noise levels (see *ESNIB* 89-10:2-3).

The analysis methods used at RAE include the usual classical modal analysis techniques, boundary-element methods, and finite-element methods. These methods are useful for low-frequency problems, but lose their efficacy at higher frequencies. In these ranges, Copley mentioned the potential utility of high-frequency asymptotic modal techniques proposed by Dowell and the stochastic FEM techniques in use at the Office National et d'Etudes et de Recherches Aerospatiales (ONERA) and developed by Soize (see *ESNIB* 88-10:1-2). According to Dr. Copley, it was one of Dowell's results, (reportedly, that the means high-frequency response is independent of the damping factor) that lead to their interest in a derivation of Statistical Energy Analysis (SEA) via a wave approach. I should add that Dowell's result seems perfectly reasonable to me, but one that Copley finds somewhat unacceptable.

Statistical Energy Analysis

With Copley's remarks as introduction, K. Heron discussed a wave derivation of the SEA. Such a derivation, according to Heron, will allow one to bring SEA into the mid-frequency range which, for a helicopter application, lies in the range 50 to 500 Hz. The SEA is applicable in this range, but is less useful because the predicted variance of the results increases with decreasing frequency.

The assumptions used in the analysis is (1) incoherence between incident and reflected wave fields at the junctions between systems, (2) estimates the coupling loss factors between systems that would arise from transmission between two semi-infinite systems (this means neglecting that part of the field in a given system that can be attributed to reflections from boundaries other than the one being considered), and (3) random incidence. Without going into detail, he includes the effects of structural offsets, such as those produced by asymmetrical attached stringers and ribs; predicts the variance as well as the mean response; and allows him to better understand the limitations of the SEA approach. Although I do not understand all the nuances of SEA, I think this work is very reminiscent of work that G. Maidanik, David Taylor Research Center, Bethesda, Maryland, is doing.

I hope to follow up with a more complete description of the structural acoustics efforts at RAE. I will base my comments on an actual site visit.

British Brain Drain
by Robert D. Ryan

The brain drain issue is in the media again. As reported on television and in the press on February 7-8, 1990, over 1,600 British scientists living and working abroad signed a petition to Mrs. Thatcher asking the government to reverse the brain drain and stop starving British science. Four members of a group that call themselves British Scientists Abroad presented the petition at

10 Downing Street. These people flew to England from Europe and the U.S. at their own expense.

Two young British scientists, Matthew Freeman and Simon Hughes, who hold postdoctoral positions at the University of California, started the petition movement. They formed British Scientists Abroad after the British Education Minister, Robert Jackson, challenged British universities to present evidence that the brain drain is real. Support for the idea spread quickly across the U.S., Europe, and other parts of the world. More than half of the people signing hold senior academic positions or senior research jobs in commercial firms. Surprisingly, 24 of the signatories are Fellows of the Royal Society. One hundred are department heads and 86 percent have PhDs or higher qualifications. The vast majority, 75 percent, were working in the U.S., while 14 percent were in Europe and 7 percent in Australia.

On February 8, *The Independent* quoted Dr. Angus Lamond, a Glaswegian holding a PhD in molecular biology from Cambridge University and working in Heidelberg at the European Molecular Biology Laboratory, as saying, "We are here to present 1,600 reasons for the Government to acknowledge the decline in British science. For the economy to boom, it is essential that money be invested in basic research." He warned that the brain drain is likely to increase if Britain takes no remedial action. He said, "The efflux of British scientists is stimulating the economies of the countries they are going to." Dr. Lamond indicated that the U.S. alone expects to have to recruit more than 500,000 scientists and engineers from abroad over the next 15 years and are likely to look to "the under-resourced and underpaid British."

Professor Michael Duff, formerly at Imperial College London but now at Texas A&M University, Bryan, feels that a whole generation of British physicists has already been lost. "Where are the missing physicists aged 25 to 40?," he asked in an interview with the media. He said that the dean of science at Texas A&M regards British universities as "the happy hunting grounds" where "there are lots of very big brains on very small salaries."

Motivated by the petition and these statements, I contacted several British computer scientists to assess informally the situation in computer science. I spoke with people working both inside and outside the U.K. They all felt that computer science research and computer science education are underfunded. For example, schools are awarded £3,500 per year per student in computer science, although they receive £4,500 per year per student in engineering and technology. The Universities Funding Council determines these awards. The issue is not just low support for students; the overriding issue is support for research, and this is low for all sciences. Several British scientists remarked about the number of alpha-rated proposals (those top-rated in the peer review) that are not funded.

I spoke with Professor Alex Cullen, retired head of electrical engineering, University College London, and a Fellow of the Royal Society. He is a member of *Save British Science*, a pressure group formed to persuade the government that the situation is indeed serious. Professor Cullen said that if one counts people leaving and people coming into Britain, the numbers do not look too bad. However, his group feels that the numbers do not tell the true story because quality is not considered. The talk about quality fails to penetrate government thinking. A statistic supporting the claim that many top scientists leave Britain is that 8 of the 40 recently elected Fellows of the Royal Academy live and work outside the U.K., 5 being in the U.S.

The young people I spoke with, who are lecturers in London, were quick to point out the lack of support for alpha-rated proposals. They noted that they and their colleagues would receive one award for every 3 or 4 alpha-rated proposals produced. This amounted to an inordinate amount of time spent writing proposals. Regarding salaries, they pointed out the particular problem in London, saying that it was almost impossible to pay for a mortgage on a lecturer's salary. And finally, there was the increased emphasis on accountability--the endless paperwork involved in accounting for items purchased and for space, heat, and light.

The Independent published an editorial on this issue on February 9 pointing out the need for increased support for research, but also that the whole infrastructure required more support. "Britain should indeed invest more in basic research, but as part of an overall commitment to investing in human resources at every level, from the schools, through apprenticeship and training to the research laboratory." The editorial argued that the rationale for a strong research establishment should not be tied solely to economic performance, an argument that history has shown to be weak in the short to midterm. "The real argument is that the quality of a society's overall response to the challenges of change--in education, in improving the environment, and in its political choices, as well as its quest for industrial prowess--will be beneficially affected over time by its ability to use what scientists have to teach."

Hearing and reading about the situation in Britain, I had a strong feeling of déjà vu, as would anyone involved in the funding and infrastructure of science and engineering in the U.S. during the last few years.

The Queen's Award for Technological Achievement 1990
by Robert D. Ryan

The 1990 Queen's Award for Technological Achievement was conferred upon the Oxford University Computing Laboratory. The award went jointly to the Oxford Computing Laboratory and INMOS Ltd. for developing

formal methods for the specification and design of microprocessors.

This is the first time that a department at Oxford University has achieved this distinction. The Computing Laboratory is one of only three university research groups among this year's 175 award recipients. The award reflects directly upon the Computing Laboratory's Programming Research Group (Group), and it represents a singular distinction for formal methods.

For American readers, I point out that this award for an organization is similar to an individual receiving the Order of the British Empire (OBE) or a knighthood.

The award cites the development of occam, the programming language that implements Professor C.A.R. Hoare's Communication Sequential Processes (CSP). Occam was the first commercially available language to address seriously the problem of programing multiple instruction stream/multiple data stream (MIMD) parallel machines. In particular, occam is the language of the transputer-based family of parallel machines. The award cites the application of occam and formal methods to developing the floating-point unit (FPU) of the IMS T800 transputer. Several members of the Group and graduates from the Group working at INMOS performed this award-winning work.

INMOS had begun a traditional, informal development that involved writing a prototype library of routines to implement American National Standards Institute/Institute of Electrical and Electronics Engineers (ANSI/IEEE) Standard 754-1985 and subjecting them to extensive testing. When this was well under way, management decided that another team would perform formal development using the specification language Z to capture formally the IEEE standard. This process exposed some inconsistencies in the informally stated standard, which relies partially on natural language. The recasting of IEEE 745 into Z was unambiguous and was the standard for the correctness of the T800 FPU.

The team derived a suite of routines from the Z specifications. Comparing these with the earlier prototype exposed errors in the prototype, some of which testing had exposed and others which testing had not uncovered. They documented the microcode that would implement the floating-point instructions in a restricted subset of occam. Using the occam transformation system developed in the Group, the team showed that this code was equivalent to a more naturally expressed occam program. They had shown before that this latter program met the Z specification. Thus, they proved formally that the microcode was correct, where "correct" means conforming to the IEEE standard as specified in Z.

Formal development quickly overtook the traditional one, which INMOS abandoned. INMOS produced the FPU a year ahead of schedule, under budget, and right the first time. INMOS has been producing the resulting

chip in volume for over two years, and users have not detected an error in the FPU. When this chip development began, most, and probably all, other commercial implementations of IEEE 754 contained known errors.

The Office of Naval Research partially supported the research of several people involved in this success for formal methods.

New Oxford Company Devoted to Formal Methods
by Robert D. Ryan

Computer scientists and mathematicians from Oxford University, U.K., and universities in the U.S. have founded Formal Systems, a company with branches in the U.S. and U.K. Formal Systems is dedicated to services in formal methods, parallel computer technology, numerical analysis, and new mathematical modeling techniques. The U.S. branch, called Formal Systems Design & Development Inc., was incorporated in 1986. Formal Systems (Europe) Ltd. was founded in the U.K. in late 1989 and is based in Oxford, U.K. Formal Systems is wholly owned by its directors.

The founders intend to direct their expertise toward the revolution taking place in parallel computing. They believe that many problems in science and engineering can run quicker and cheaper by using better software on the new generation of inexpensive parallel computers. Dr. Mike Reed, a founder of Formal Systems (Europe), cited an example from molecular dynamics. Starting with code originally written for a Cray supercomputer, they rewrote the code to run on a desktop, transputer-based parallel machine. The code ran faster and cheaper on the small machine than it did on the supercomputer.

The collective experience of Formal Systems is particularly well founded in areas of computer science and numerical methods, including formal specification languages, programming-environment tools, very large-scale integration (VLSI) design, molecular dynamics, fluid dynamics, and numerical methods for solving large systems of partial differential equations, nonlinear filtering, signal processing and high-speed data/image compression, system analysis, and military engagement modeling. Formal Systems (Europe) concentrates on applications of formal methods and consultancy in parallel computing. Services offered by Formal Systems (Europe) include:
- Application of formal methods to the specification and development of program code and computer hardware
- Advanced consultancy on parallel computer technology
- Development of specialized software tools.

Formal Systems (Europe) offers standard or customized industrial short courses in areas of expertise. These include the specification language--Z, the theory

of parallel computing expressed in Professor Hoare's Communication Sequential Processes (CSP), Timed CSP, the parallel programming language--occam, and transputers.

The two branches of Formal Systems have the same directors. The directors resident in the U.S. are Drs. J.W. Newberger, T.S. Quarles, P.L. Zenor, and Ms. C.L. Zenor. Drs. G.M. Reed, J.N. Reed, and A.W. Roscoe are resident directors of Formal Systems (Europe). Among the staff of Formal Systems (Europe) is Dr. M.H. Goldsmith, who serves as Chief Technologist. Drs. G. Jones and J.C.P. Woodcock are primary consultants. These Oxford personnel are currently on the staff of the Computing Laboratory at Oxford University, except Dr. Goldsmith, who has recently left the Laboratory to work full time for Formal Systems (Europe).

Currently, Formal Systems has service contracts with several large industrial companies, including General Electric Company Inc. and Battelle Laboratories, U.S., and INMOS Ltd., U.K. In recent years, the staff has directed research projects with several million pounds funding from sources in the U.K. (Alvey, IED, SERC), the EC (ESPRIT), and the U.S. (Office of Naval Research).

A recent article in the Sunday Times (London) described the hard times of many small high-technology companies in Cambridge, including the fact that Cambridge RISC Machines had gone into liquidation. In contrast, the article mentioned the health of several new high-technology companies based in Oxford. Among those mentioned were Formal Systems, Oxford Molecular, Oxford Glyco Systems, and British Biotechnology.

Society for General Microbiology Spring Meeting 1990
by Keith E. Cooksey

Introduction

The Society for General Microbiology (SGM) spring meeting was held at the University of Warwick, Coventry, U.K., April 9-12, 1990. This is a particularly convenient venue for a scientific gathering since the university campus originally was built with the idea that holding conferences would be a secondary source of funds. The meeting was organized around theme symposia run by the individual groups of the SGM. A symposium on extremophiles, for instance, was supported by posters on a similar subject. Although many of the 14 symposia presented contained individual papers of importance to Office of Naval Research (ONR) programs, two of them were of particular naval interest.

Immobilized Cell Processes

The first theme symposium presented by the "Fermentation Bioprocessing Group" of the SGM was entitled Immobilized Cell Processes. Five papers were presented

covering the field from the regulation of the physiology of slowly growing cells to the engineering aspects of their commercial exploitation. Most microbial physiological and genetical information is based on studies of logarithmically growing cells. Comparatively, little is know about nongrowing or very slowly growing cells, yet these situations exist commonly in nature and almost always in commercially exploited immobilized cell processes.

The first talk in the symposium addressed this topic. Dr. Stouthamer, Free University, Amsterdam, emphasized the concept of maintenance energy in micro-organisms (introduced by Professor John Pirt in the 60s). He explained that many published values for the maintenance energy parameter, based on plotting the microbial specific growth rates versus molar growth yield, are incorrect. He explained the practical difficulties of measuring vanishingly small growth rates at low substrate concentrations in a chemostat. He also mentioned that many studies that sought to measure maintenance energy by extrapolating to zero growth rates curves based on relatively fast growth, are also flawed. In other words, the classical chemostat is useless in this area of science! Furthermore, Dr. Stouthamer emphasized that cells growing slowly have different physiologies from cells growing quickly. For example, protein turnover is greatly enhanced at slow growth rates. Again, cells growing slowly often instigate an *alarmone* mediated stringent response to incipient starvation. To study the phenomenon of very slow growth, Dr. Stouthamer encouraged the use of the fed-batch reactor or a fermenter which contains a recycling loop. His research suggests that immobilized cells have reduced substrate uptake rates and metabolic capabilities. The biotechnological implications of these are obvious. Implicit in his conclusions is extrapolating measurements made on rapidly growing suspended cells to biofouling studies directed at understanding biofilm processes in general, are not warranted.

Also in the symposium was a paper by Dr. Michael Dempsey, Manchester Polytechnic, Manchester, U.K. He described the use of coke (end-product of coal/gas manufacture) as a novel microbial cell support in a fluidized-bed reactor. Coke has convenient specific gravity for use in such a reactor as well as providing multiple anchorage sites for cells. Dr. G. Kuenen, Delft University, Delft, the Netherlands, explained the use of immobilized *Thiosphaera pantropha* biofilm for effluent treatment. Dr. Kuenen emphasized that environmental research is a priority for the European Community (EC). The biofilm mentioned here was exceedingly thick (2mm) so using microelectrodes for chemical analysis with depth in the films was reasonable. Electrode measurements of films much thinner than this are rarely justified because of diffusion problems along the edges of the electrode. *T. pantropha* has mixotrophic physiology and Dr. Kuenen explained how this is beneficial to an organism living in

an industrial effluent stream of varying composition. Dr. Kuenen also described a device to hold biofilm-covered glass beads so microelectrodes could be inserted easily and reproducibly.

Dr. M. Lilly, University College, London, gave the view of the biochemical engineer. As we have come to expect from engineers, his presentation was down to earth! He stressed that immobilized cell reactors in commerce are justified only if a definite processing advantage is proved, because as yet, there are no inherently biological reasons to use them. Such advantages, if they are found, usually occur downstream of the reactor. An idea novel to me is the use of temperature-sensitive mutants to control the undesirable growth of immobilized cells used merely as catalysts in biotransformations. In such situations, cells grown and immobilized at a permissive temperature could be used at a nonpermissive temperature for the transformation. Dr. J. Griffith, Center for Applied Microbiology and Research, Porton Down, U.K., described mammalian cells immobilized in or on various supports. He described the advantages of hollow-fiber reactors (O_2-transport, waste product transfer, large surface for anchorage-dependent cells) as well as their major disadvantage (scale-up problems). He believes the most successful system for scaling up of immobilized mammalian cell processes is based on a stacked-plate reactor, although microcarriers are most frequently used by others.

Finally, Dr. N. Emery, Department of Chemical Engineering, University of Birmingham, U.K., undertook the unenviable task of summarizing the whole symposium. In his summary, he also introduced several concepts not considered previously. For instance, he believes the proposed advantage of immobilizing cells to protect them from hydrodynamic shear is exaggerated. He also preferred the term *hydrodynamic excess* to shear. He also talked of the concept of *togetherness*--a rather colloquial term used to explain cellular metabolic regulation based on the proximity of other cells. Dr. Emery deplored the lack of quantitative thought by many biologists. For instance, although enhanced rates of chemical reactions catalyzed by immobilized cells were mentioned frequently by biological scientists, few ever gave figures! Dr. Emery believes that *in situ* nuclear magnetic resonance measurements may be the best way to obtain such figures. This symposium is reported with greater detail in the Office of Naval Research European Office Report on Immobilized Cell Research, summer 1990.

Extremophiles

Also of interest was a symposium on *Extremophiles*! Much of the discussion concerned the taxonomy of these organisms--especially that of *Thermus* sp., once thought to be a single species genus. This focus was to be expected because the SGM "Systematics Group" organized the symposium. However, one of the practical interests in those organisms that live outside the human temperature range is biotechnological. The basic idea behind their use in biotechnology is that the stability of their enzymes is greater at high temperature (more than $70^\circ C$) than those from mesophiles. However, turnover numbers for enzymes from the thermophiles are not usually higher than those from mesophiles. Thus, any advantages from their use at high temperatures are limited to those related to the instability of competing enzymes (usually from contaminants) at those temperatures. Dr. Richard Sharp, Center for Applied Microbiology and Research, Porton Down, pointed out that elevated temperatures in bioreactors cause problems related to the decrease of medium O_2 solubility, evaporation, and toxicity of plastics. Apparently, many in the audience did not know that plastics that are nontoxic at $25^\circ C$, can become toxic at $70^\circ C$!

Dr. D. Cowan, University College, London, reviewed biocatalysis in non-aqueous solutions. Non-aqueous milieu are useful where the substrate for a biocatalyzed reaction is very nonpolar and thus very insoluble in water. Enzyme activity in non-aqueous environments, it appears, runs in parallel to thermal stability--a situation that reflects the degree of folding of the protein catalyst.

Apparently from this symposium, extremophiles are no longer ecological curiosities. Work was presented on all aspects of their taxonomy, biochemistry, and molecular genetics.

A question broached at the symposium (but not settled) is the means by which biocatalysts able to operate at elevated temperatures will be produced for commercial purposes in the future. Will they be purified from thermophiles or will the genes specifying them be introduced into more conveniently grown mesophiles? Further, once the protein structural rules defining thermostability are known, will it be advantageous to engineer enzymes from mesophiles for stability? If so, it should be possible to use them at elevated temperatures where their turn-over numbers, other things being equal, may also be increased.

This symposium was illustrative of the relative research strengths of two U.K. laboratories. Seven of the 16 papers presented in this symposium came from either University College, London, or the Center for Applied Microbiology and Research at Porton Down. Also notable was the strong influence of Dutch microbiologists in these areas of science. Other topics in the symposia included psychophiles, halotolerant algae, thermophilic sulfur-metabolizing bacteria for use in mining, as well as general papers on Archebacteria.

The ROSAT Mission

by Raymond G. Cruddace, X-Ray Astronomy Branch, Space Science Division, Naval Research Laboratory, Washington, D.C.

Introduction

The ROSAT satellite was launched on 1 June 1990 from the Kennedy Space Center (KSC) on board a Delta 2 launch vehicle. The satellite is an astronomical observatory whose primary instrument is a large x-ray telescope. The satellite is the first launching since the end of the highly successful U.S. Einstein Observatory, operating at wavelengths between 6 and 120 A (0.1 -2 keV). The satellite's principal goal is a detailed survey of the whole sky. This should yield an x-ray source catalog containing roughly 100,000 objects located with an approximate precision of 30 arc seconds. This will be the primary x-ray catalog in the astronomical community for many decades. Naval Research Laboratory's (NRL) Space Science Division is taking an active role in this effort. The division maintains working relations with the Max Planck Institut (Institut für Extraterrestrische Physik [MPE]) in Garching near Munich, which is the institute in Germany responsible specifically for the ROSAT mission. The Royal Observatory (ROE) in Edinburgh is aiding in identifying the x-ray sources that ROSAT will find. The ROSAT's mission is described here, as well as MPE and ROE activity summaries. Our interests in these endeavors are twofold, namely scientific exploration and problems of handling large databases.

ROSAT Satellite Description

The Bundesrepublik finances ROSAT as part of the national space program. The satellite, weighing over 2 tons and having dimensions of roughly 4x4.5x2.2m in its orbital configuration, finished its last all-up systems test in Germany, December 1989. The satellite was shipped to KSC in January 1990. The primary instrument, an x-ray telescope (XRT), contains four concentric (nested) grazing-incidence reflecting mirrors. The instrument has an outer diameter of 0.83m and a focal length of 2.3m. At the focal plane are three imaging x-ray detectors sitting on a motor-activated carousel. The carousel can position any one of the three at the telescope focal point. The three include two identical position-sensitive proportional counters. One high-resolution imager (HRI) uses microchannel plate (MCP) x-ray sensors. Table 1 summarizes the telescope's characteristics.

In addition to the XRT, ROSAT contains a smaller U.K. instrument, the Wide Field Camera (WFC), sensitive to longer wavelengths (60-700A in a number of separate, selectable wavebands). The grazing-incidence mirrors are nested, like the XRT mirrors, but of shorter focal length and field of view. The WFC contains MCP detectors in the focal plane. Its characteristics are summarized in Table 2.

Table 1. Summary of the Main Characteristics of the ROSAT X-Ray Telescope

Mirror

Focal length	240 cm	
Aperture diameter	84 cm	
Unobstructed aperture collecting area	1141 cm^2	
Angular resolution on axis	5 arc sec (FWHP)	
Mean grazing angle	2 deg	

Focal Plane Detectors	**PSPC**	**HRI**
Spatial resolution (FWHM)		
at 0.93 keV	300μ	20μ
at 0.28 keV	400μ	
Energy resolution (FWHM)		
at 0.93 keV	0.43	—
at 0.28 keV	0.80	
Bkg. count-rate in orbit: cts/sec (arc min)^2	2x10-3	1x10^{-3}

Telescope

	PSPC	**HRI**
Field of view (dia.)	114 arc min	38 arc min
Angular resolution (FHWM; on axis)		
at 1 keV	25 arc sec	6 arc sec
at 0.28 keV	34 arc sec	
Peak effective collecting area	225 cm^2 (1.1 keV) 360 cm^2	130 cm (0.9 keV)^2 80 cm^2

Table 2. Summary of the Main Characteristics of the ROSAT Wide Field Camera

Mirror

Focal length	53 cm
Aperture diameter	58 cm
Unobstructed aperture collecting area	450 cm^2
Mean grazing angle	7.5 deg

Telescope

Field of view (dia)	5 deg
Angular resolution on axis	2 arc min (FWHP)
Background count-rate: survey filter 1	~ 1x10^{-3} cts/sec (arc min)^2
(Carbon/Lexan/beryllium) survey filter 2	~ 1.3x10^{-3} cts/sec (arc min)^2
(beryllium/Lexan) Peak effective collecting area: survey filter 1	33 cm^2 (135 e.v.)
survey filter 2	45 cm^2 (100 e.v.)

The ROSAT Mission

The Bundesrepublik, the U.S., and the U.K are collaborating on the ROSAT mission. The Bundesrepublik provides the satellite, ground control facilities, and primary data processing; the U.S. provides the launch and the HRI for the XRT focal plane; the U.K. supplies the WFC. The ROSAT was launched into a 580-km high circular orbit with an inclination of 57 degrees. For the first 2 months, it will undergo a thorough orbital checkout. The all-sky survey will occupy the following 6 months.

During this time, the satellite will rotate uniformly allowing the telescope to scan a circle on the sky. The normal to the scan plane points constantly at the sun, allowing the scans to systematically cover the whole sky during the 6-month survey. The rotation period is equal to the orbital period, so the telescope never views the earth.

The survey data belong to the Bundesrepublik and the U.K., and will be analyzed in Europe, but U.S. scientists have not been excluded from the analysis. Participants have been invited from several institutions. However, this has resulted from willing individuals working at MPE for extended periods, both before and during the mission. Currently, there are about 1,000 known x-ray sources, and the ROSAT may raise the figure to about 100,000. The positional accuracy, now typically of order 1 degree, will improve to a fraction of an arc minute.

Upon completion of the survey, ROSAT will embark on a series of pointed observations. This will have a minimum duration of 1 year and is expected to last several years. The U.S. is allocated one-half percent of this time, the Bundesrepublik about one-third, and the U.K. about one-sixth. The first proposals for these pointed observations have been completed.

NRL Activities Regarding ROSAT

The Space Science Division at NRL is involved in the ROSAT survey in two respects--the study of clusters of galaxies and the optical identification of x-ray sources. Clusters of galaxies, that is associations of anywhere between one hundred and several thousand galaxies, are a common and pervasive element of cosmic structure. They contain hot gas at temperatures between 10^7 and 10^8 K, sufficient that they are copious sources of x rays. The ROSAT will detect a large sample of clusters (at least 3,000), the most distant being at redshifts of about 1. Using the spatial distribution of this sample, we will be able to trace the large-scale matter structure in the universe. The evolution of clusters may be studied measuring the luminosity distribution of various distance ranges. In recent years, the idea that the universe at our epoch was relatively uniform has been challenged by observation and theory. In addition, the concept that evolution (if present at all) was relatively slow has also been challenged. Within the framework of theoretical models in which cold dark matter controls the dynamics of cosmic evolution, it may be possible that the universe contains a great deal of structure. This structure is voids, sheets, and filaments in the galaxy distribution, and its evolution may be proceeding vigorously at our epoch. The ROSAT cluster observations provide strong tests of these ideas.

However, such research (and indeed many other ROSAT research projects) cannot proceed unless the x-ray sources are identified. While existing optical, infrared, and radio catalogs will be useful in this respect,

most of the roughly 100,000 sources will be new discoveries. Primarily, identifying them will involve a correlation with detailed optical surveys of the complete sky using Schmidt (large, wide-field) telescopes. The first undertaking was several decades ago in the northern sky at Mount Palomar. More recently, the U.K. has been undertaking a survey of the southern sky in Australia. Correlation of these surveys with all-sky surveys at other wavelengths is too slow if the photographic plates are consulted directly. Therefore, strenuous efforts are being made to scan these plates photometrically and digitize the information. This is a mammoth task because there are about 800 plates (5.3x5.3°) per hemisphere, and one photographic plate contains a prodigious amount of information. At a spatial resolution of 16 microns, one plate requires about 320 Mbytes of storage, so one sky hemisphere requires about 260 Gbytes, equivalent to 130 optical disks (1 Gbyte/side). This is already four times larger than the expected ROSAT x-ray survey database.

The ROE is responsible for the scanning and digitization of the U.K. Schmidt southern hemisphere survey. The NRL and ROE are producing a compressed form of the database, suitable for use at MPE during the ROSAT data analysis. The data produced by the scanning is analyzed to find every object on the plate (mostly stars and galaxies). At that time, the salient characteristics of each object, such as position, intensity, size, and shape are stored in a highly compressed format. The result will be a database comprising about 8 Gbytes for the whole hemisphere.

Digitized optical surveys will be valuable in various scientific activities, not least astronomical research; it is envisaged that these databases will be accessible to all. Various studies using the U.K. Schmidt southern hemisphere data are underway already. These studies include a search for clusters of galaxies by ROE and NRL, supporting their ROSAT interests.

Report on 22nd Europhysics Conference on Macromolecular Physics Structure Formation in Polymer Solution, Leuven, Belgium, September 25-27, 1989

by Oh-Kil Kim. Dr. Kim is a Research Chemist at the Naval Research Laboratory, Washington, D.C.

This conference was held at Katholieke Universiteit, Leuven, Belgium, on September 25-27, 1989. The Foundation Sigma Pi, in collaboration with the Flemish Chemical Society (VCV) under the auspices of the European Physical Society, organized the conference. Leuven is a historic, as well as academic town. Leuven's university, established in 1425, is one of the oldest in Europe. Having an advanced science meeting in such a historic site as *Groot Begijnhof* (established in the 13th century) was very impressive.

Structure formation is a phenomenon that occurs through a specific macromolecular interaction mediated directly or indirectly by solvent. During the last decade, a discovery was made that some synthetic polymers such as polyethylene (PE), poly(methyl methacrylate) (PMMA), and poly(styrene) exhibit an unusual structure in solution, although this is common in biopolymers. In recent years, there has been a growing interest in Gelation of polymer solutions. Polymer gels are often a highly ordered form and a precursor of ultra high-strength crystalline fibers. The PE gelation is a typical example of this phenomenon and has proved useful in practical applications.

Generally, physical gelation occurs through liquid/liquid phase separation in polymer solution and subsequent crystallization of concentrated domain. However, the detailed mechanism involving solvent molecules is still unclear; therefore, many discussions were concerned with the mechanisms and resulting gel's morphology. There were invited lectures, contributed papers, and posters on the conference program. The conference's topics were thermodynamics, mechanisms, and kinetics of structural formation, morphology, rheological aspects, and industrial applications. Many presentations were concerned with polymer gels. Sixty-five papers were presented, including posters; half of the presentations were invited lectures and communications. Of the 150 registered participants, the majority were from European Economic Community countries, 12 from the Eastern Block countries, and 6 from the U.S.

A few of the 18 invited lectures gave topical reviews. R. Koningsveld, University of Antwerp, Belgium, gave an overview on the phase behavior of ordered polymer solutions of liquid crystals, block copolymers, and blends in terms of classic equilibrium thermodynamics. A. Keller, University of Bristol, U.K., discussed polymer gelation and phase segregation, and related molecular requirements for gelation, gelation mechanism, morphology, and mechanical properties of various polymers. Crystalline gelation of PE as well as vinyl polymers involves a complex molecular process for ordering depending on solvent, annealing temperature, and concentration.

H. Berghmans, Katholieke University, Leuven, Belgium, is a pioneer in phase behavior studies of gels. He developed temperature-concentration phase diagrams of many polymers to investigate the gelation mechanisms. J.M. Guenet, Université Louis Pasteur, France, proposed a model for polystyrene gelation (in decalin) which proceeds via the creation of an order, forming an intercalation structure with the solvent molecules. Gelation of stereoregular PMMA may be dependent on solvent quality: transparent gels form in good solvents and glassy gels form in poor solvents.

According to J. Spevacek, Czechoslovak Academy of Science, stereoregular PMMAs have a strong tendency to form an ordered aggregate. He further claimed that the conformational structure of crystalline forms of stereoregular PMMA is a double helix from the results of nuclear magnetic resonance (NMR), infrared (IR), and x-ray studies. However, there was a dispute over the structure raised by E. Atkins, University of Bristol. Another interesting structure formation in a fully linear chain molecule is with polyethylene oxide (PEO)/p-dibromobenzene (PDBB) system. J.J. Point, Université de Mons-Hainout, Belgium, explained that the host/guest molecules form crystalline intercalates in which PEO is associated with PDBB. He concluded that the conformation of the PEO molecule is a 10/3 helix.

Unlike the gel formation of synthetic polymers, gelation of polysaccharides such as alginates and pectates occurs in aqueous solution. E. Atkins, University of Bristol, reviewed the molecular aspects of polysaccharides gelation. He emphasized that, besides the helical backbone, the side group structure of polysaccharides and their spacial arrangement along the backbone control their preference of interaction towards either gelation (in the presence of Ca^{2+} ions) or mesophase structure. There were other presentations on related subjects. The conclusions were more or less along the same lines.

Other polymer ordering systems occurring in aqueous solution (other than polysaccharides) are synthetic polyelectrolytes and lyotropic liquid crystal polymers. Interpolymer complexation occurs commonly between oppositely charged polymers, often resulting in phase separation. V.A. Kabanov, Moscow State University, U.S.S.R., discussed a unique ternary complex system. The system produces a thermoreversible gel through the formation of a balanced interchain cross-linking that takes place at a controlled stoichiometry. This is a new approach to the molecular ordering. Among other presentations regarding polyelectrolyte complexation, O.-K. Kim, Naval Research Laboratory, reported an unusual polyacrylic acid (PAA) self-complexation. This occurs only with ultra-high molecular weight PAA in high-shear flow, resulting in a rigid-chain morphology through H-bonding, but without phase separation. There were several reports on rheological studies of polymer gels and ionomer solutions. Some were concerned with flow-induced structural changes in ordered fluids.

Most poster presentations were concerned with gelation mechanisms and characterization of gel structures. Other topics covered solution properties of ion-containing polymers, rheological properties of physical gels, polymer complexation, flow properties of lyotropic liquid crystal polymers, and polymerization.

Research Workshop on Computational Condensed Matter Physics: Total Energy Methods and Physics of III-V Semiconductors

by Karel Kunc, Laboratoire de Physique des Solides Associé au Centre National de la Recherche Scientifique

The workshop, Total Energy Methods and Physics of III-V Semiconductors, took place from January 4-6, 1990 at the University of Pierre and Marie Curie, Paris. Sixty-six scientists participated. There were 26 invited speakers from 12 countries: U.S., U.K., Switzerland, Italy, Austria, Belgium, Czechoslovakia, France, German Democratic Republic, Federal Republic of Germany, Japan, South Korea, and Turkey. The scope of the meeting included applications of the Density Functional Theory (DFT), the Car-Parrinello method, theory of pseudopotentials, and semiconductor surfaces. Also, the meeting included new materials (III-V superlattices, high-T_c superconductors, and magnetic thin films)--subjects exhausting a large, and possibly the essential part of the computational solid-state physics.

The workshop's aim was bringing together the principal personalities employing the DFT and the Car-Parrinello methods, as well as those studying new materials. The workshop's goals were to discuss current projects and formulate recommendations for further research.

In the last few years, the DFT became a powerful method for studying material properties, which derive from the electronic ground state. After several years of testing and applying the method, this approach may be used for predicting those properties of materials which are unknown experimentally (because the experiments are either impossible or too difficult) and for studying new materials, the synthesis of which is then attempted. We can quote as an example the research on hydrogen in Si and GaAs, or the study of *hard materials*. Within the latter project, a large number of results on bulk moduli B_0, were previously obtained by *ab initio* calculations, and allowed to establish *empirical* formulas accounting for the results to 1 or 2 percent. These expressions suggested a definite trend for obtaining *hard* substances (large B_0): small lattice constant and a weak ionicity parameter. By manipulating simple algebraic expressions, the Berkeley group succeeded in proposing as candidate the β-C_3N_4. A complete study by the DFT then confirmed that this substance should have properties similar to diamond. The same reasoning also suggested that nitrogen absorption at the diamond surface should enhance the hardness of this substance.

The linearized density functional method, combines the DF and the linear response theories and appears as an extremely powerful tool for studying linear phenomena, such as phonons. This approach uses the *classical* random phase approximation expressions for calculating the inverse dielectric matrix $\varepsilon^{-1}(q+G,q+G')$, starting from the DF electronic ground state. In terms of the dielectric matrix, one then evaluates the linearized expressions for Δp resulting from a displacement u (or from another perturbation). The energy variations caused by this Δp, are then easy to calculate. An extraordinary efficiency of this approach was demonstrated by the phonons study in III-V superlattices (E. Molinari).

Among the numerous nonlinear phenomena (where the linearized DFT does not apply), one can quote the band offsets in the GaAs/GaSb heterojunctions (A. Qteish). The *full* DFT makes it possible to obtain reliable values for ΔE_v with better precision, in fact, than the resolution of the contemporary experimental methods would allow (photoemission of the core electrons).

Superlattices are one example of the *new materials* that were thoroughly debated at the meeting: magnetic thin films and high-T_c superconductors are the other two. The superlattices Co/Cr and Fe/Cr exhibit striking magnetic properties which can be advantageously used in construction of magnetic memories. A theoretical study of lattice vibrations in the substances of the La/Ba/Cu/O family allowed precise determination of the frequencies of selected phonons. The accuracy may be comparable with that of spectroscopic measurements, if only the latter could identify all the measured peaks clearly.

An essential novelty of the last 2-3 years is the Car-Parrinello method, which sprung from combination of the DFT with the techniques of molecular dynamics. The method is a particularly efficient technique of finding the exact atomic structures (energy minimization with respect to several structural parameters). Also, this technique makes possible studying the systems at nonzero temperatures, as well as the nonequilibrium systems.

Besides the atomic structure works on microclusters of III-V semiconductors, and on different phases (both solid and liquid) of carbon, a particularly satisfactory application of the method is (in my opinion) re-establishing the 2x1 reconstruction of the silicon surface (F. Ancilotto). A convincing evidence by total energy minimization has already been presented by the past. Nevertheless, one notices that the energy calculations had started by assuming a particular atomic arrangement; then, eventually, the energies of selected structures could be compared. This time the Car-Parrinello method leads directly towards the structure of minimal energy, without assuming one at the onset. The final arrangement, indeed, turns out to be a 2x1 reconstruction.

In the above-method framework, most groups are now questioning the mathematical techniques that would guarantee that the energy-minimum found by the procedure is, indeed, the absolute minimum and not one of the local minima (*simulated annealing* versus *steepest descent* techniques). In this context, the *conjugated gradient* technique was developed, and we were witnessing a polemics about its infallibility.

Another way of combining the DFT with molecular dynamics, viz. partition of Hamiltonian into a *classical* and a quantum-mechanical parts, is practiced by quantum chemists to study very large systems: proteins consisting of 1,250 atoms and 100 water molecules.

Although the pseudopotential concept is to some extent a technical matter, this notion has developed quite considerably since the idea of norm-conserving pseudopotentials was proposed by Hamann, Schlüter, and Chiang in 1979; these pseudopotentials are generated by *ab initio* calculations on atom. This year we have seen the norm-conservation requirement abandoned, and new pseudopotentials proposed which are truly nonlocal: $V_\ell(rr')$ instead of $V_\ell(r)$, with the ℓ being the angular momentum. Pseudopotentials of this new generation are able to describe the transition elements; also, their transferability has improved. There is a truly *technical* but significant detail: a simple test was proposed (S. Froyen) where, by performing calculation on a *compressed* pseudo-atom (pseudopotential enclosed in a well), one can judge how well the pseudopotential in question will perform in solid. The tests, used so far, have not been sufficiently demanding, they consisted of good reproduction of several excited states of the atom.

All the results shown during the workshop, as well as all the techniques employed, are based on using, in large scale, the supercomputers. They represent a large part of what is termed computational physics of solids. New computer architectures and the latest developments in supercomputers were presented by A.R. Williams, Thinking Machines Corp.: the Connection Machine, which is ideally suited to solution of differential equations. The flexibility of the architecture allows restructuring its 64,000 parallel processors into 2-, 3-, 4-dimensional arrays. A massive parallelization is an emerging trend which, in short- and medium-term, may be the only path to increasing the computing power dramatically. If so, one has to foresee that all the existing codes will have to be retouched, or rewritten entirely. The new Fortran 8x (in preparation) will offer some aid, it is hoped, at least.

The next workshop of the series will take place on January 16-18, 1991 in Trieste, Italy. The contact person is R. Resta, International Centre for Theoretical Physics/Scuola Internazionale Superiore di Studi Avanzati.

Regional and Mesoscale Modeling of Ice-Covered Oceans

by Ruth H. Preller and Shelley Riedlinger, Naval Oceanic and Atmospheric Research Laboratory, Stennis Space Center, Mississippi

Introduction

A workshop on Regional and Mesoscale Modeling of Ice-Covered Oceans was held at the Solstrand Fjord Hotel in Os, Norway, October 23-27, 1989. Fifty-eight scientists attended the workshop. The attendees were from Norway, the U.S., Canada, Finland, Denmark, Italy, Sweden, England, Germany, New Zealand, Japan, and the U.S.S.R. More than 50 percent of attendees were Europeans, the majority Norwegians; there were 20 U.S. scientists.

Presentations

Formation of Eddies, Jets, and Vortex Pairs. The first session focused on observations and methods for modeling eddies in the Marginal Ice Zone (MIZ). The focus was also on currents in the Fram Strait, in the East Greenland Sea, and in the Sea of Okhotsk. Presentations indicated that ice-edge eddies are observed in a variety of regions such as the Greenland Sea, the Labrador Sea, and the Sea of Okhotsk. Ice-edge eddies have often been seen to exist as vortex pairs, two counter rotating gyres. In the open ocean, such vortex pairs are often attributed to jet flow. At the ice edge, localized jet flow has been suggested as a driving mechanism for these vortex pairs. Bottom topography and the destabilizing effect of horizontal shear were also suggested as mechanisms for eddy formation.

Dr. Doron Nof, Florida State University, Tallahassee, suggested that anticyclones dominate cyclones in the ocean because only cyclones meet the necessary condition for vortex splitting. When eddies split, they are pushed from the center of rotation and acquire additional planetary torque. Only cyclones, which rotate in the same sense as the earth and therefore have more angular momentum, have enough torque to allow splitting.

Marginal Ice Zone and Interior Ice Dynamics. In session two, several aspects of interior ice dynamics were discussed. The subjects addressed included internal ice stresses and various types of rheologies, interaction of meandering ocean jets with the ice edge, ice dynamics and radiated sound, reflection of ocean waves at the ice edge, and the development of a statistical model for floe breakup. Several speakers examined different types of ice rheologies. These rheologies can affect ice thicknesses and ice velocities in ice modeling. Plastic rheologies with an elliptical yield curve have proven useful in the past. Other rheologies were examined to determine if they could improve ice models. These preliminary studies produced new rheologies which can replace the rheology currently used. The methods discussed included a Mohr Coulumb failure criterion, cavitating fluid, and the expression of the stress-strain rate relation as an ideal granular material. A method's study of finite element discretization of deformations and stresses in sea ice was also addressed.

The interaction of ocean jets with the ice in the marginal ice zones was modeled. This model showed that including internal ice stress, in which resistance to convergence but not divergence is incorporated, resulted in

banding of the ice near the outer ice edge. This did not occur with free-drift models. In a similar vane, the acoustical ambient noise generated by the interaction of ocean eddies and the ice edge was presented. An interesting feature was observed from analysis of several eddies in the Barents and Greenland Seas. This feature was that the noise level in the eddy centers was 3-5 dB above the open ocean noise level and 8-13 dB above the interior ice pack level. This increase in noise was associated with ice convergence in the eddies.

Many of the discussions were highly mathematical and concentrated on small-scale dynamics within sea ice. Possibly, understanding these small-scale dynamic processes will further improve ice modeling.

Data Blending and Assimilation Techniques and the Barents Sea

There was a variety of subjects in session three. Dr. Ruth Preller, Naval Oceanographic and Atmospheric Research Laboratory (NOARL), showed how the U.S. Navy's sea-ice forecasting system--the Polar Ice Prediction System--is initialized once per week from observations. These observations are a digitized form of the ice concentration analysis from the Naval Polar Oceanography Center. The model forecasts are highly dependent on the quality and the timeliness of the initialization. In a region like the Arctic where data is scarce, a useful approach would be to use a data blending scheme. This could incorporate all available data into one *best guess* initialization field. Dr. Abe Cheng (U.S., Sverdrup Technology, Inc.) presented such a scheme. His scheme used linear regression and weighing of the data sets to create a single *best guess* field.

Two different type of models for the Barents Sea were also presented. Dr. Tom McClimans, Trondheim, Norway, presented the first model, designed as a rotating tank experiment. This model used the appropriate bottom topography and geometry for the shallow Barents Sea. The circulation, driven by buoyancy and Coriolis effects alone, revealed a complicated system of strong currents in fairly good agreement with observation. A current drawback for this model was the failure to include the real open boundary effects.

Peter Haugen, Nansen Remote Sensing Center, Norway, presented ice-drift results from the second Barents Sea model, an ice forecasting model run by the U.S. Navy. These results were compared to observations from drifters put into the Barents during the Seasonal Ice Zone Experiment during February 1989. The comparison showed that the model could not accurately account for the observed motion, particularly over the 3- to 5-day forecast. The problem is partly attributed to errors in the atmospheric forecast, and partly the lack of detail in the ocean currents used by the model. These results related

well to the previous talk; the talk showed that the currents in the Barents can be very swift and variable.

Finally, Dr. Preller's second presentation showed how dependent ice models are on atmospheric forcing. The model results quickly reflect the inaccuracies in the atmospheric forcing. Since ice models require a larger number of atmospheric forcing fields than most ocean models, small errors in each field can accumulate and result in large errors in the model forecasts.

Coupling of Sea Ice to Atmospheric and Oceanic Boundary Layers

Session four examined the processes involved in the transfer of momentum, heat, and salt between the air-ice and ice-ocean. In the study, several numerical models, as well as some data analysis, were used. Both Arctic and Antarctic conditions were considered. Much attention was given to the development of the boundary layer between the air and ice and between the ice and ocean. This session dealt significantly with formulation and application of drag laws. One author discussed the importance of form drag on the edge of small ice floes to the momentum and salt exchange. His study showed that ocean form drag, which in general tends to slow momentum, is important on floes less than 300 m in diameter, and that air-ice form drag tends to accelerate flow on floes less than 50 m in diameter. His work implied that numerical ice-ocean models, which do not consider this type of form drag, generally overestimate ice velocities. Another participant showed that the free-drift assumption with a linear drag law can be useful in ice-divergence cases. He examined a quadratic drag law, a linear drag law, and the omission of the Coriolis force in the momentum balance. He found the same degree of accuracy when all were applied to a winter data set in the Weddell Sea. Even in conditions of high ice concentration, the linear drag can be useful as an *effective* drag.

Other areas discussed were the annual ice mass and corresponding mixed-layer properties fluctuations for a 100-year period from 1880-1985, the advance/retreat cycle of the ice edge, and the response of the oceanic mixed layer. In general, these models showed that vertical mixing and summer conditions can delay the build-up of the ice cover the following winter.

Sea Ice-Ocean Coupling in Large-Scale Circulation Models

This session addressed several different approaches to coupling ice models to ocean models. Hibler's sea ice model was used most frequently. Most emphasis was on the coupling and type of ocean model to use. The heat transfer between the ocean and ice was shown as the dominate process to consider developing the coupling.

Several speakers showed that horizontal and vertical advection within the ocean was the largest contributor to the oceanic heat flux, with vertical mixing being important

when complex temperature and velocity fields are present.

Several participants ambitiously attempted fine resolution models of the Arctic and Antarctic. The Antarctic model was .5° by .25° horizontal resolution with 32 levels vertically in the ocean. The model covered the Antarctic between 25° south and 79° south. This model is a joint effort by several British institutes with the Scott Polar Research Institute, University of Cambridge being one. The Arctic model, by the Danish Hydraulic Institute, has .5° horizontal resolution and 6 vertical levels in the ocean. Also, the Arctic model considered digitized surface winds and barometric pressure as forcing fields. Both models are still in development and hope to reproduce dynamic and thermodynamic processes in polar regions.

Several three dimensional (3-D) models of the Arctic, with somewhat coarser resolution, were presented. Participants from NOARL presented two of these models. Both used the Hibler ice model and forcing fields from the Fleet Numerical Oceanography Center's atmospheric forecast model--NOGAPS. The first model coupled the ice model to the Bryan/Cox ocean model to develop an ice forecast model that better incorporates the oceanic influence on the ice. The second model included a mixed-layer model, and examined two different treatments of the ocean circulation. In one case, the geostrophic velocity was obtained from an inverse beta-spiral. In the other case, the barotropic velocity was calculated prognostically. The remaining 3-D model examined long-term effects by employing a 50-year integration of the Hibler and Bryan ice/ocean model.

A few models were more specific in areas and processes examined. One model examined the seasonal ice advance and retreat over the continental shelf. This model used idealized forcing, Hibler's ice model, and a six-level ocean model. The results from this model showed that convective overturning transfers oceanic heat stored in the lower ocean and inhibits ice formation, that northerly winds contribute to heavier ice cover, and that cross-shelf circulation increases exchange between the cold shelf and warmer offshore waters that reduces ice formation. Another model was a one-dimensional ice/ocean model that included a mixed layer-pycnocline model of the ocean.

Summary

Overall, the workshop presented an excellent description of state-of-the-art modeling of ice-covered oceans. To obtain a book of abstracts or proceedings, contact the Nansen Remote Sensing Center, Edvard Griegsvei 3a, N-5037 Solheimsvik, Bergen, Norway.

Royal Society of Chemistry Faraday Discussion 89

by Dr. Karl M. Robinson, Chemistry Division, Surface Chemistry Branch, Naval Research Laboratory, Washington, D.C.

Introduction

This conference was held April 3-6, 1990, at the University of Manchester. The conference's general discussion was the wealthy discovery of new information about surfaces and interfaces of various systems from synchrotron radiation sources. The major European and American synchrotron community representatives presented short accounts of their experimental results followed by open discussions. The organizers recorded these discussions which will be a major part of the meeting's published results.

The scope of the presentations focused on various x-ray techniques as primarily applied to solid interfaces, although liquid interfaces were mentioned. A few techniques included Extended X-Ray Absorption Fine Structure (EXAFS), X-Ray Absorption Near Edge Structure (XANES or NEXAFS), Reflectivity, Total Reflectivity Bragg Diffraction (TRBD), and X-Ray Photoemission. These interfaces consisted of macroscopic single crystals, clean and with adsorbed layers, semiconductors, zeolitic cage surfaces and liquids.

Highlights

Dr. A. Bradshaw, Fritz-Haber Institute der Max-Planck-Gesellschaft, Berlin, Federal Republic of Germany, presented the opening session. Dr. Bradshaw outlined present research on the Cu(110)-O surface. In particular, he compared the results of various techniques, low-energy electron diffraction, transmission electron microscopy with data collected from TRBD studies. The agreement between the techniques was very good except in the oxygen atom location in the missing row model. In conclusion, he emphasized the need to further analyze this system and the advantages of synchrotron radiation in the surfaces analysis.

Four presentations were made during the first full session. The papers discussed glancing incident EXAFS and reflectivity of transition metals and semiconductor layers. Also discussed were EXAFS of thin films on Fe/Cr and time-resolved EXAFS in conducting polymers. The discussion focused on the particular samples and the usefulness of EXAFS and XANES in glancing mode. Two papers presented theoretical approaches to glancing incidence EXAFS, as well as novel experimental designs that could take full advantage of the full potential EXAFS offered.

The second session opened with the XANES studies identifying the SOx surface species on $TiO_2(110)$. This paper demonstrated using synchrotron polarization to identify the bond direction on the surface. In this session,

the following papers showed standard transmission EXAFS on various samples. The EXAFS data analysis was heatedly discussed during these papers. Two distinct analysis procedures were addressed. In the paper by Dr. R.W. Joyner, University of Liverpool, data was fitted by a single scattering model. He claimed that within statistical error, his model sufficiently explained the EXAFS information. Several groups countered this argument following the presentations by Dr. D.C. Koningsberger, Eindhoven University of Technology, who uses a multiple scattering theory to obtain better data fits. There was no distinct result from this debate; however, error analysis should be followed through carefully for all models.

The third session involved using scattering techniques at the interfaces. Opening this session was Dr. I.K. Robinson, European Synchrotron Radiation Facility, Grenoble, who discussed the structure and roughening of the Pt(110) surfaces. Two papers discussed semiconductor interfaces--reconstruction after monolayer deposition and the stress relaxation of a multilayer expitaxily grown on a crystalline substrate. Dr. R.A. Cowley, University of Oxford, introduced a theory explaining the line shapes of scattering and reflectivity results. Two papers concerning liquid surfaces were also discussed. The first paper, Dr. S.A. Rice, University of Chicago, proposed crystalline shape theory and island formation of Langmuir films on the liquid surface. The second paper, Dr. P.S. Pershan, Harvard University, discussed theoretically and experimentally, using reflectivity measurements in determining the perpendicular surface density of liquid surfaces.

The meeting's fourth and final session discussed many different x-ray analysis techniques. The first paper discussed core-level shift spectroscopy on W(110). The second returned to XANES but at the metal/organic and metal/polymer interfaces. The third paper used angle-resolved, photoemission spectroscopy to analyze the structure of surface methoxy species on Cu(111). The fourth paper introduced the concept of normal-incidence standing x-ray wavefield absorption. This paper had a short section on the principles of standing waves and their use in surface structure analysis. The fifth paper discussed photoelectron diffraction of the O, N, and C adsorption on Ni(100) and Cu(110). The final paper used SEXAFS to study the adsorption of Xe gas on the Cu(111) surface.

Summary

The meeting clearly showed the synchrotron experimentation's impact on surface structure determination. The conference's international makeup proved the world-wide interest in the advances that synchrotrons have provided in surface analysis. The meeting's papers and the verbal commentary will shortly be published as Faraday Discussions 89. Direct questions concerning the conference and subsequent publications to Mrs. Y.A. Fish, Royal Society of Chemistry, Burlington House, Piccadilly, London W1V OBN, U.K.

Advanced Materials and New Techniques Impacting Oxidation Research

by Dr. A. John Sedriks, Materials Division, Office of Naval Research, Arlington, Virginia

The international conference on Microscopy of Oxidation was held March 26-29, 1990, University of Cambridge, U.K. The sponsors were the Institute of Metals, the Institute of Physics, and the Royal Microscopical Society. Over 80 delegates attended from 14 countries, with 11 from the U.S. The Institute of Metals, 1 Carlton House Terrace, London SW1Y 5DB, U.K., will publish the proceedings.

The purpose of the conference was assessing the advances in the state of knowledge about oxidation. Specifically, this is knowledge derived from the direct observation and analysis of oxides, together with the identification of factors that influence oxidation reactions. Microscopy was interpreted in its widest sense to include secondary ion mass spectroscopy (SIMS), Auger, low-energy electron diffraction, and x-ray photoelectron spectroscopy. Also included were the *true* microscopies such as transmission electron microscopy, scanning electron microscopy, and optical microscopy.

The 35 papers and 30 poster papers were grouped within the traditional oxidation subtopics of alumina formers, chromia formers, and iron oxides. Two sessions were devoted to newer techniques. Among the latter were using microlithographic markers, using the Fresnel Method in transmission electron microscopy, hot-stage microscopy to 550°C, Raman laser spectroscopy, and electron energy-loss spectroscopy.

The meeting's dominant feature was the number of papers devoted to advanced materials. These included intermetallics (i.e., titanium aluminides, Ni_3Al, Al_3Nb), mechanically alloyed materials (e.g., Ni-20Cr-0.3Al-0.5Ti-0.6 Y_2O_3), metal-matrix composites (e.g., Al-SiC), novel niobium alloys (e.g., Nb-49Al,22Ti), carbon-carbon composites, and compound semiconductors (e.g., CdTe and ZnTe).

Keynote papers were: Kofstad, University of Oslo; Graham, National Research Council, Ottawa; Smialek, NASA Lewis; Grabke, Max-Planck; and Castle, University of Surrey, U.K. A brief discussion of their papers follows.

Kofstad provided some new insights into the mechanism by which water vapor accelerates the oxidation of chromia-protected alloys. He argued that water vapor provides proton defects that accelerate oxidation by changing conductivity, interacting with majority defects (e.g., Ni and O interstitials), interacting with minority defects (e.g., vacancies), and accelerating grain boundary transport.

Graham addressed the mechanism by which *reactive elements* such as Ce decrease oxidation rate. He presented data showing that the deposition of ceria coatings on iron-chromium alloys decreases oxidation rate for deposit thicknesses up to 4 nm. At greater thicknesses, the effect becomes constant, with no further increase with deposit thickness. Oxygen 18/SIMS results suggest that when Ce is located within the oxide scale, there is a change in oxide growth mechanism from predominantly cation to predominantly anion diffusion. The inward diffusion of oxygen is a slower process, accounting for the decreased oxidation rate.

Smialek presented data supporting the view that sulfur decreases alumina scale adhesion. In addition, the increase in scale adhesion caused by reactive element addition is because of their ability to getter sulfur. (This NASA work directly follows earlier Office of Naval Research-supported work at United Technologies Research Center which led to the formulation of these concepts.) Using a commercial superalloy, Smialek showed that excellent scale adhesion occurs if sulfur segregation to the scale interface is limited to one-fourth of a monolayer. Also, spallation is expected if total segregation exceeds 4 monolayers.

Grabke discussed sulfur segregation described by Smialek and the pest phenomenon in intermetallics. About sulfur, Grabke noted that sulfur segregates to a free surface, but that Auger sections do not show sulfur segregation at the scale-metal interface. He suggested that the mechanism by which sulfur aids scale spalling may involve sulfur stabilizing the voids forming at the interface by vacancy condensation. Sulfur would exert the stabilizing influence by decreasing surface energy. Later discussion questioned whether monolayer segregation would be detectable in Auger sections, leaving the exact sulfur mechanism in question. The pest phenomenon was studied in the intermetallic $NbAl_3$ and identified as intergranular disintegration caused by preferential oxygen diffusion along grain boundaries and the formation of Al_2O_3 at these sites. The phenomenon is temperature dependent, reaching a maximum at approximately $750^{\circ}C$.

Castle devoted his closing keynote lecture to reviewing the surface analysis techniques available to studying oxidation, emphasizing the wealth of information that can be derived from photoelectron spectroscopy (e.g., revealing the differences between spinels and single oxides, between valence states, and between cations associated with different anions [chlorides and oxides]). He also noted useful applications of scanning tunneling microscopy in oxidation research.

Overall, the meeting left the impression that oxidation research has risen to the challenges posed by new techniques and advanced materials availability. Also, the research is poised to lead and support new technologies in the high-temperature area. With the possible exception of oxide ceramics, all the new advanced materials will need some degree of protection from oxidation. Continued financial support for research and development, in this area, should remain a priority for all national agencies interested in advancing high-temperature technology.

Fractals in Physics

by Michael F. Shlesinger, Office of Naval Research, Arlington, Virginia

An international meeting on Fractals in Physics was held in Vence, in the south of France, October 1-4, 1989, to honor Benoit B. Mandelbrot the *father of fractals*. In homage to fractals, it was held on his 64.86028..th birthday.

In the early 1970s, renormalization group treatments began investigating critical phenomena by treating the dimension as a continuous variable. Certain problems that were hard in three dimensions (3D) were easy in four dimensions (4D), because in 4D mean-field theory became valid. For example, a self-avoiding random walk in 4D is like a regular random walk. The reason is the walker has little chance to intersect its own previous trajectory. However, in 3D, the properties of the self-avoiding random walk have never been analytically solved, although good approximations can be obtained. Calculations for several types of critical phenomena in 4-e dimensions were pursued, with e treated as an initially small perturbation parameter, and then hopefully close to one. At the time, Mandelbrot was alone in asking what 4-e dimensions looked like. To most scientists, this question did not make sense. He had asked this question before (and supplied answers) in many contexts. In this process, he was creating a new paradigm, changing from a Euclidian to a fractal geometric description of nature. He had also investigated the role of scaling in fields such as economics and linguistics.

Mandelbrot's quest led him to studying self-similar and self-affine geometries. His mathematics, models, computer simulations, and intuition strongly suggested that much nature geometry does involve fractal sets. Is there anyone today who does not think of a cloud as a fractal? M. Berry, Bristol, U.K., said, "Fractal geometry is one of those concepts which, at first sight, invites disbelief, but on second thought becomes so natural that one wonders why it has only recently been developed."

Today, the fractal concept is well known, even in the popular press. Essentially, fractals are a geometric shape with features on many scales that relate to each other through scaling relations. The Mandelbrot set formed by iterations in the complex plane of the quadratic map has created exquisitely beautiful pictures. The pictures have subtle variations over an infinite number of scales that art exhibitions and books have devoted to its various aspects.

Fractal art is used to create realistic natural scenes in science fiction movies and computer games. Also, fractal techniques were used in novel methods of image compression. One thinks of the fractal dimension as the ultimate data compression with a single number characterizing a continuous data stream.

The meeting's major theme was showing that the exponents in physical scaling relations are related to fractal geometric sets. A major advance in the 1970s was discovering that the scaling exponents found in critical phenomena did have their roots in fractal sets, such as the percolation cluster. The 1990s developments showed that these fractal ideas were applicable to a host of scientific problems, including nonequilibrium and dynamical systems. Biological structures, such as the lung, are also providing a fertile field for fractal analysis.

Undoubtedly, Mandelbrot's paradigm is a success. The paradigm is ascribing the proper geometry to natural objects and seeking a geometric meaning for the fractional scaling exponents found in nature. Problems that were previously difficult to tackle (because of a complex geometry) have become amenable because of the fractal paradigm. Now even undergraduates study topics such as diffusion on percolation clusters. H.E. Stanley, Boston University, Massachusetts, described hands-on experiments and computer simulations that students can perform to investigate fractal shapes and dynamics.

The focus of the Vence meeting was fractals in physics. A. Aharony, Tel-Aviv University, Israel, brought out that a fractal can have many fractal subsets that are themselves fractal, albeit with fractal dimensions different from the whole object; e.g., the percolation cluster with the percolation backbone as a subset. The set of fractal dimensions is called the multifractal spectrum. Mandelbrot introduced the concept in the context of dissipation in turbulent systems. In 1974, he calculated corrections to Kolmogorov's inertial range scaling by following through the consequences of assuming that dissipation is concentrated on a multi-fractal set. Aharony pointed out that when calculating multifractal dimensions, in practice, care must be taken in differentiating between average and typical values of a quantity. Average values can be skewed by a single large input giving a different scaling from typical (more prevalent) values.

K. Sreenivasan, Yale University, New Haven, Connecticut, studied the geometric properties of the turbulent interface of a dye jet injected into a fluid. Interesting multifractal regimes were found in the gradients of space and time concentration fluctuations. This was when the fluid viscosity and dye diffusivity were nearly equal, and when their ratio was small. W. Goldberg, University of Pittsburgh, Pennsylvania, continued the geometric study of turbulence via light scattering studies from small particles suspended in a turbulent flow. His results showed that energy containing eddies occupy a fractal region whose dimension increases with Reynolds number. This saturates in the Kolmogorov regime where the relative velocity u of two initially nearby particles grows with distance R as $R^{1/3}$. M. Shlesinger, Office of Naval Research, theoretically investigated fractal random walk paths where distances R are traversed with a velocity proportional to $R^{1/3}$. In the limit where no space scale exists, Shlesinger found that Richardson's law of turbulent diffusion (mean-squared distance proportional to time cubed) is recovered.

At first, the focus in fractals was finding a multitude of proof-of-principle examples that fractal shapes do exist in nature. Next, new techniques such as multifractal measures were introduced to analyze these shapes. Many growth models were introduced (e.g., diffusion-limited aggregation) that produced fractal shapes. A. Skjeltorp, Institute for Energy Technology, Kjeller, Norway, discovered a new technique to form a fractal. He dried uniformly sized polystyrene spheres on a substrate to form a thin film. Upon drying the capillary forces between the spheres dominated the attraction to the substrate to allow the formation of patterns with fractal geometries of holes of all sizes. Why fractal shapes occur is now being addressed. P. Bak, Brookhaven National Laboratories, Upton, New York, has proposed an idea called self-organized criticality to understand the formation physics of fractal shapes. His initial model as applied to the formation of a sandpile is discussed to illustrate the main idea. As sand is added to a sandpile, its cone-shaped structure becomes steeper. This steepness reaches a critical angle beyond which growth cannot occur. At steeper angles, avalanches will occur and bring the pile back to a less steep angle. The pile can grow to a critical angle; i.e., its critical shape is determined by a marginal stability. At the critical angle, the addition of more sand will cause an avalanche. This will then cause cascading avalanches further down the slope. In this theory, the distribution of avalanche sizes and time scales is algebraic (scaling). One not only gets fractal spatial changes, but fractal (1/f-like noise) time properties as well. Basically, the theory says growth occurs until a critical state is reached. At that point, small changes propagate through the structure in a scale invariant manner. Bak has not only used this idea for sandpiles, but for topics from earthquakes to the distribution of burning suns in the universe. L. Pietronero, University Roma *La Spaienza*, Italy, (in a different approach) treats fractal growth structures for diffusion processes, Laplacian fractals, as attractors in a dynamical system whose fixed points determine the fractal dimension. J. Feder, University of Oslo, Norway, introduced a hierarchy of branch orders to study diffusion-limited aggregation and viscous fingering. His results point to both phenomena being in the same universality class.

The fact that growth processes can lead to fractal shapes can be significant. For a nuclear winter scenario, M. Berry, calculated the rate that smoke particles would fall out of the atmosphere. A fractal cluster of 1,000 spherical particles, of dimension 1.8, would fall 10 times more slowly than a spherical cluster of the same mass. Observations of smoke clusters did measure dimensions of about 1.8. Another facet of nuclear winter is the scattering of light by fractal objects. S. Sinha, Exxon Research and Engineering Co., Annandale, New Jersey, examined the scattering from surface and mass fractals. The Fourier transform of the position-position atomic correlation function yields a power-law behavior as a function of the inverse wavelength. This implies fractal structure. Also, it is found in aggregated colloids, gels, biological systems, polymeric materials, rocks, ceramics, and even metallic systems. Diffusion-limited and cluster-cluster limited diffusion models lead naturally to fractal shapes. R. Jullien and R. Bottet, University of Paris-Sud, France, actually built fractal objects using several thousand spheres to confirm fractal scattering laws in the geometric optics limit. The aforementioned self-organized, critical phenomena can provide a foundation for understanding the formation of fractal shapes. In terms of nuclear winter, fractal smoke clusters will not only fall more slowly than spherical clusters, but will also absorb light in a manner to make a colder nuclear winter.

R. Orbach, UCLA, Los Angeles, California, theoretically investigated the dynamics of fractal structures focusing on elementally vibrational excitations called fractons. E. Courtens, IBM, Zurich, used Brillouin, Raman, and incoherent neutron scattering on silica gels to find experimental results for the fractal dimension, vibrational spectral dimension, internal length scale exponent, and density of states that were completely consistent with Orbach's predictions.

Flow through porous media has many fractal aspects. E. Guyon, École Superiore de Physique et Chemie Industrielle, France, points out that Hammersley introduced the percolation cluster in 1957 following Broadbent's curiosity about the clogging of gas masks. This is an excellent example of good research deriving from practical applications. However, even though the percolation cluster is a standard fractal shape, there is no fractal structure involved in flow through coffee grounds in a percolator. Despite the lack of a fractal structure, Guyon discussed that by selecting sublattices, (in decreasing order of permeability) a percolation-like threshold for flow exists. R. Lenormand, Institut Francais du Petrole, Rueil-Malmaison, France, stressed the importance of fractal concepts in petroleum engineering, but pointed out that more work had to be done before using such approaches to describe realistic situation. A major problem is models that may agree with laboratory experiments are not applicable to large-scale reservoirs. For example,

in a successful model called invasion percolation, capillary forces determine flow at pores. While this works well at small scales, viscous forces would dominate the large-scale structure.

Many other topics were covered. In the field of biology, I. Giaever, Renssalaer Polytechnic Institute, Troy, New York, experimentally studied the motion of normal versus cancerous lung fibroblast cells. The cells were cultured on gold electrodes and their motion was recorded as an electrical voltage time series. A Hurst analysis (which can detect fractal correlations) finds significant differences between the two cases. This could open a new technique for the early cancer detection, or a quick test during exploratory surgery to determine if cancer cells are present. Usually, single cells do not yield this information. Only the abnormal clumping of many cells would differentiate cancerous from healthy cells. F. Family, Emory University, Atlanta, Georgia, found that the human retinal blood vessels have a self-similar structure with fractal dimension of 1.7. This value is consistent with a diffusion-limited model for the retinal growth process based on the motion of angiogenic factors inducing retinal growth. M. Fisher, University of Maryland, Silver Spring, Maryland, discussed the statistical mechanics of two-dimensional vesicles, such as red blood cells, to show that they can achieve fractal shapes as pH, osmotic pressure, and temperature are changed.

Many other interesting topics were discussed ranging from the role of fractals in evolution, to fractal aspects of fracture, to models of growth, to the structure of the universe, to the structure of cauliflower (microscopic to macroscopic structures), to fractals in music. For the interested reader, the proceedings can be found in *Physica D*, Volume 38 (1989). A closing remark of C. Domb, Bar-Ilan University, Ramat-Gan, Israel, is however abstract and remote mathematics may seem; e.g., early fractal-like inventions of say, Weierstrass, Cantor, and Hausdorff, there is no escaping that it might someday be put to practical use.

11th International Vacuum Congress and 7th International Conference on Solid Surfaces

by Dr. Richard W. Vook, Professor of Physics, Syracuse University, Syracuse, New York

Introduction

11th International Vacuum Congress and 7th International Conference on Solid Surfaces took place in tandem in Cologne, Federal Republic of Germany (FRG), September 25-29, 1989. There were approximately 1,020 research papers presented at this meeting, held every 3 years at various locations around the world. Papers were presented orally and by posters in surface science, ap-

plied surface science, thin films, vacuum science, electronic materials, fusion technology, and vacuum metallurgy.

I attended sessions that presented invited papers on surface science, applied surface science, thin films, and electronic materials.

When the plenary sessions were ended, the main talks began. Typically, there are 10 simultaneous sessions followed by poster presentations. Approximately 1,450 persons attended all or parts of the conference. An equipment exhibit accompanied the talks, but did not appear as well attended as the annual American Vacuum Society meetings.

Each conference participant received a large book of abstracts. Proceedings that will be published in the journal, *Vacuum*.

Plenary Session

The conference started with three interesting plenary lectures. (Short talks by various administrators in Cologne, FRG, preceded lectures.) Dr. Riesenhuber, Federal Minister for Research and Technology, made some interesting points. He mentioned that Germany and Japan spend 2.9 percent of gross national product on science research, while the U.S. spends 2.5 percent. He discussed the status quo of research in the 1970s; i.e., there were no big breakthroughs then. In the 1980s, however, new major technologies were created. Thus, research policy, according to him, should not try to forecast the future. New, dramatic developments can happen anytime. Freedom of research is necessary; it must be independent and not goal-oriented. Thus, basic research policy by government or private agencies should be very cautious because ideas do not come from top-down but rather from bottom-up. Finally, one of his last topics was a discussion of the internationalization of research in Germany and the rest of Europe, which seems to be well developed.

Following the introductory talks, Dr. C.W. Chu and Professor E. Bauer each presented a plenary lecture. Dr. Chu reviewed the developments that led to high T_c superconductivity and the status of the field. Clearly, developments in this field represented an excellent example of the bottom-up type of research discussed by Dr. Riesenhuber.

Professor Bauer discussed the details and applications of his new instrument, a Low-Energy Electron Microscope (LEEM). This instrument represents an enormous improvement over low-energy electron diffraction (LEED) because it allows one to do microscopy (including video microscopy) from the first one or two monoatomic layers on a surface. The LEEM supplements the earlier Japanese developments on Reflection High-Energy Electron Microscopy. Examples of LEEM results included: (1) the preferred nucleation and growth of surface adsorbates (metals, gases) at imperfections and steps; (2) surface phase transformations (e.g., Si 7x7 on [111]); (3) sublimation from surfaces that is inhibited by impurities that cause hillocks to form instead. Dr. Bauer developed the instrument using funds from the automobile manufacturer, Volkswagen, and is commercially available for 2 million DM (approximately $1 million). The significance of this instrument being available for general use (if you can afford it) cannot be overestimated. One need only recall the advances made when transmission electron microscopy supplemented the earlier high-energy electron diffraction studies.

General Sessions

There were many interesting presentations at this conference but, because of its size, one could attend only a few. The invited papers were particularly good. I have chosen to comment on a few invited papers as well as several contributed papers.

D.T. Pierce, National Institute of Standards and Technology, Gaithersburg, Maryland, talked on Surface Magnetic Microstructure. The studies were carried out by scanning electron microscopy with polarization (i.e., spin) analysis, which measures all three components of the magnetization (probe depth 1nm). With this technique, it was possible to see the magnetic microstructure of domains and domain walls and obtain high-resolution images. The authors showed, for example, that Bloch walls are converted to Neel walls at the surface.

Oepen, the Free University of Berlin, described the use of similar techniques to study the magnetic microstructure of 3-9 monolayer thick fcc Co films grown epitaxially on Cu(100). As-grown films consisted of single domains. Demagnetization with an AC-field produced stable domains approximately 100 um in size and with 90° and 180° domain walls. The magnetization lay in the film plane and had < 100 > easy axes.

R.L. Johnson, MPI für Festkörperforschung, Stuttgart, FRG, described X-Ray Diffraction Techniques for Surface Structure Determination using synchrotron radiation. After briefly reviewing the literature in this area, he reported results on 1-20 monolayer thick GaAs films grown on Si, Au on Si(111), and Pb on Ge(111). He has a transfer chamber in which he prepares his specimens, and then wheels over to the synchrotron and does conventional diffraction through a hemispherical Be window. Kinematic theory can be used to interpret the results. The x-ray wavelength usually used is 1.3Å. Experiments in the U.S. are carried out at Stanford and Brookhaven. Abermann, University of Innsbruck, Austria, reviewed Internal Stress in Thin Films. His talk consisted of a discussion of his group's results using the bending beam technique in ultra high vacuum for Cu, Ag, Au, Al, Fe, and Cr films and the effects of H_2O, CO, and O_2 partial pressures during deposition on the resulting internal

stress. Stresses were measured as a function of gas exposure, film thickness, and deposition temperature. They obtained a wide range of results. Apparently, there are still some unexplained problems in the interpretation of the data. Nevertheless, this is a very important area of research because stress in thin films can have a variety of deleterious effects in practical applications. More work using ultra high vacuum techniques is needed in this area.

H. Neddemeyer, Ruhr-Universität Bochum, FRG, presented a very interesting series of applications of the Scanning Tunneling Microscope on Nucleation and Early Stages of Film Growth. Examples were given first of Si(7x7)(111) and Si(2x1)(100) surface atomic structures. They were followed by STM photos of the growth and morphology of fractional monolayers of Ag and Cu on the Si(111) 7x7 surface. Atom clusters, flat islands, double positioning twinning, and Cu silicides were among the phenomena observed at different stages and conditions of growth. Neddemeyer showed that in the early stages of growth, Ag atoms go to the Si dangling bonds and that Cu atoms form at two levels, the lower one forming possibly a silicide.

G. Ertl, Fritz-Haber, Institut of the Max Planck Gesellschaft, Berlin, presented an interesting paper on Temporal and Spatial Self-Organization in Oscillatory Surface Reactions. The basic phenomenon consists of damped oscillations in catalytic reaction rates while many variations have also been reported. The underlying mechanism consists of transitions between states of low and high reactivity such as adsorbate-driven surface reconstruction on the formation of a subsurface phase. Ertl's work dealt largely with various bulk platinum, single-crystal surfaces.

W.J. Kaiser, JPL, California Institute of Technology, Pasadena, talked on Scanning Tunneling Microscopy (STM) Investigation of Semiconductor Interfaces. Normally, one thinks of STM applications only to surfaces, but the ballistic electron emission microscopy (BEEM) technique uses STM to investigate metal-semiconductor interfaces with nanometer resolution. One scans over a surface and obtains an image (caused by the collector current) of the metal-semiconductor interface. However, Kaiser found that the Au/Si(100) interface is smooth while the Au/GaAs interface is rough and defective.

Y. Chabal, AT&T Bell Laboratories, presented a paper on Molecular Diffusion on Metal Surfaces: Time-Resolved IRS and Other Techniques. Chabal showed how IRS could be used to detect C0 molecules adsorbed on Pt(111) terraces and steps and get their relative concentrations on these two kinds of sites, all from the same spectrum. Measurements could also be made of these various concentrations as a function of time.

H. Oppolzer, Siemens, Munich, FRG, discussed Transmission Electron Microscopy (TEM) of Layered Structures and Interfaces. Cross-sectional TEM was used to investigate interfacial regions as thin as one monolayer. Also, chemical information was obtained on a 1-nm scale. Some of the topics discussed were interfacial segregation in 1-mL wide grain boundaries, oxide formation at interfaces (sometimes the oxides ball up), the effects of Zn interdiffusion of GaAs-GaA1As superlattices (Zn enhances interdiffusion and destroys the superlattice), YBaCu0-SrTi0$_3$ interfaces (there is a reaction zone there).

Ichikawa and Doi, Central Research Laboratory, Hitachi, Tokyo, presented a paper on Observation on Electromigration Effect Upon Si-MBE Growth on Si(001) Surface. They described current-induced surface step motion that was attributed to electromigration effects. On the (001) Si surface are located 2x1 and 1x2 terraces. When the direct current flowed in one direction, one of the terraces (e.g., 1x2) grew at the other's expense. A reverse current caused the other terraces (e.g., 2x1) to grow preferentially. The electric current effect was temperature dependent and influenced surface structure and crystal growth. I raised the question of current density, and Ichikawa said that at 800°C, it was 100 A/cm^2, a rather low value at which to see electromigration phenomena.

The paper by J. Klatt, Institute for Semiconductor Physics, Frankfurt (Oder), German Democratic Republic, and P. Barna, Research Institute for Technical Physics, Budapest, Hungary, on the Correlation Between Substrate Properties and Formation of Annealing Hillocks in Al Thin Films was also interesting in view of our own work on the isothermal annealing of hillocks in Al-Cu films. Their hillocks were (001) oriented single crystals. The Al films were formed on oxidized Si using intermediate layers of MoSi$_2$ whose thickness was varied to affect the thermally induced strains in the Al films. The size of the hillocks depended strongly on the induced compressive stresses in the Al films. Barna said that there was no change in the hillocks either in density or average size as a result of isothermal annealing after the hillocks were formed initially. This result is opposite to what we found for Al-Cu films.

Marliare, IOTA, Orsay, France, presented an interesting paper in which he observed Quantum Size Effect Detected by Work Function Measurements During Indium Deposition on Polycrystalline Textured Gold Substrates.

ONREUR REPORTS AND MAS BULLETINS

Reports

To request reports, indicate the report number on the self-addressed mailer and return it to ONREUR.

Computer Science

Cable Television and Satellite Broadcasting, by J.F. Blackburn. **(90-2-C)** Sponsored by the Financial Times, this 2-day conference was the eighth in the annual series. This particular conference marks the end of the first year of the Sky Television network's operation in the U.K. The conference was held just before British Satellite Broadcasting (BSB) goes into operation.

With speakers from the U.K., the U.S., France, Japan, and the Netherlands, attendance exceeded all previous conferences. The 400 participants came mainly from the U.K., but also represented were France, the Netherlands, U.S., Australia, Spain, Norway, Canada, Switzerland, Denmark, Federal Republic of Germany, Finland, Monaco, Belgium, South Africa, Italy, Luxembourg, Irish Republic, and Malta.

ESPRIT Technical Week, Information Technology Forum Day, by J.F. Blackburn. **(90-3-C)** The European Strategic Programme for Research and Development in Information Technologies (ESPRIT) has been reviewed annually since its beginning in 1984. The ESPRIT I was completed in 1988. The Council of Ministers approved a second 5-year phase in April 1988 and 1989 represents ESPRIT II's first year of activity. The ESPRIT II work distribution is Microelectronics - 30 percent, Information Processing Systems - 20 percent, Office and Business Systems - 20 percent. The budget for ESPRIT II is 3.2 billion ECU, shared equally by participating companies and the European Community.

Held in Brussels, the Information Technology (IT) Forum Day of the ESPRIT Technical Week is devoted to speeches of EC and European Parliament speakers and their private industry counterparts who give their assessment of the program. Some of the speakers also present plans.

The U.K. Information Technology 1990 Conference, by J.F. Blackburn. **(90-4-C)** The U.K. Information Technology (IT) 1990 Conference took place at the University of Southampton, March 19-22, 1990. The conference was organized by the Computing & Control Division, Institution of Electrical Engineers, along with the British Computer Society, the Department of Trade and Industry, and the Science and Engineering Research Council. To some degree, it replaces the Alvey Conferences held annually between 1983 and 1988.

The main topics covered in this conference were each supported by several technical papers. The conference main topics were: The Cycle of Software Engineering; Knowledge, Acquisition, and Development Methodology; Security and Fault Tolerance; Systems, Concurrency, Real Time; Vision; Control Systems and Environments; Formal Modeling Methods; System, Quality, Metrics; Parallel and Distributed Architecture; Very Large Scale Integration (VLSI); Experimental Systems; Formal Aspects; System Design; Tools; Instrumentation and Intelligence; Knowledge-Based Systems (KBS); Speech Applications; Object Oriented Systems; KBS with Other Technologies; and Speed Language and Vision.

BRITE/EURAM: Third Technological Days 1990, by J.F. Blackburn. **(90-5-C)** The Third Technological Days for the Basic Research in Industrial Technologies in Europe/European Research in Advanced Materials (BRITE/EURAM) Program was held in Brussels, Belgium, May 21-22, 1990. The BRITE portion of the program concentrates on integrating several enabling technologies and disciplines, such as mechanics, optics, acoustics, and fluid dynamics in design and manufacturing. The EURAM portion deals with the development of new industrial materials and improvement of the materials life cycle of production, transformation, and recovery.

European Telecommunications Conference Strategic Planning for the 1990s, by J.F. Blackburn. **(90-6-C)** The European Telecommunications Conference Strategic Planning for the 1990s provided information to delegates and their companies on strategic planning for the European market, particularly after the advent of the European Single Market at the end of 1992. The conference objective was to examine the impact of the initiatives of the European Commission (EC) and the changing attitudes to service provision by public and private sector organizations on industry and marketing.

Organized by Blenheim Online and Logica, 40 delegates attended this conference, mainly from Europe, but with a few from the U.S. The papers were designed to illuminate such questions as emerging market sectors, impact of U.S. telecommunications organizations in Europe, mergers and acquisitions, standards, and value-added services. Brief summaries of the 15 papers presented are given in this report.

MAS Bulletins

The following Military Applications Summary (MAS) Bulletins were published between 20 April and 13 July 1990. The MAS Bulletin is an account of accomplishments in European naval research, development, and evaluation. Request copies by number from ONREUR.

11-90 Modular Sea-Skimming Towed Target System

12-90 The LR6000 - A British-Designed Long-Range Autonomous Submersible

13-90 Ocean Surface Current Radar Update

14-90 Ocean Surface Current Radar II

15-90 De-Bug Fuel Decontamination Unit

16-90 Seastreak - High Velocity Close In Weapon System

17-90 Papers Presented at Advisory Group for Aerospace Research and Development (AGARD) Symposium on Hypersonic Combined Cycle Propulsion

18-90 OBVACT Naval Gunnery Trainer

19-90 GEC Covert Radar Altimeter Type AD1990

REPORTS ON EUROPEAN SCIENCE AND TECHNOLOGY FROM OTHER COMMANDS

Reports

Information on each of the reports listed below was furnished by the following activity. Address requests to:

EOARD - European Office of Aerospace Research and Development, Box 14, FPO New York 09510

Low Noise GaAs Mesfets at Selenia, Italy, by Dr. Eirug Davies, EOARD. (5pp) [EOARD-LR-90-015]

One of the four groups at Selenia's Central Research Directorate is involved in GaAs technology. Efforts are concentrated on low noise Mesfets and microwave monolithic circuits. Surprisingly, large thermal gradients have been identified during the heating/cooling cycle of implant activation. These effects are circumvented in a specially designed vertical furnace that provides wafers of significantly better uniformity. Mesfets operating at 12 GHz and exhibiting 10 dB of gain have the lowest yet reported noise figures of 1.2 dB.

Total Dielectric Isolation from Selective Area Implantation, by Dr. Eirug Davies, EOARD. (5pp) [EOARD-LR-90-020]

A modified Simox process to provide total dielectric isolation of silicon I.C.s is being investigated at the University of Surrey, U.K. The oxygen is implanted through a mask that limits the buried oxide formation to prescribed areas. Around these areas the oxide tapers to the surface to provide side-wall isolation. Issues being addressed include retention of surface planarity and the oxide integrity within the side-wall region.

Testing Composite Structures and Aircraft Tires, by LTCOL James G.R. Hansen, EOARD. (11pp) [EOARD-LR-90-22]

Two test programs at a Darmstadt, Federal Republic of Germany, Fraunhofer Institute are of special interest:

1. Fiber-reinforced composite panels and laminate specimens are subjected to consecutive impact, fatigue, and compressive loads. The critical design criteria of compressive strength after impact is analytically modeled.

2. Special instrumentation, developed at Fraunhofer, measures tire local strain and global deformation. Measurement data is critical to evaluating finite-element models of aircraft tires. Additionally, Fraunhofer designed wheel and hub simulators have received worldwide acclaim.

Quantum Optics and Laser Physics Research, Huygens Laboratory, the Netherlands, by Dr. Stacey Lazdinis, EOARD. (12pp) [EOARD-LR-90-024]

The research in laser physics and quantum optics performed by Professor J.P. Woerdman, Huygens Laboratory, University of Leiden, the Netherlands, is summarized. Specifically detailed is his work on (1) the analogy between photon band structures and electronic band structures; (2) light-induced drift of alkali atoms; and (3) the coherence collapse of semiconductor lasers.

Solid-State Electronics Research at Philips Research Laboratories, by Dr. Vince Donlan, EOARD. (24pp) [EOARD-LR-90-025]

The Philips Research Laboratories, Redhill, England, is one of eight research centers of the Netherlands electronics company, Philips. Research at this center in solid-state electronics, informatics, and systems covers the behavior of electronic materials and devices, new devices, and their applications to new systems. This report describes recent solid-state research on growth of III-V multiquantum well structures on silicon substrates, GaAs/AlAs superlattice structures, migration of Si dopant in MBE GaAs, camel barrier cathodes in 90-GHz Gunn oscillators, MOVPE growth of MCT heterojunction IR detectors, liquid crystal color displays for flat panel television, and silicon power devices.

European Space Agency Symposium on Space Applications of Advanced Structural Materials, LTCOL James G.R. Hansen, EOARD. (11p) [EOARD-LR-90-027]

The U.S. aerospace community can learn a great deal about high-temperature, brittle matrix composites from the European Space Agency's HERMES space plane program. Parts for the HERMES thermal protection system and hot structure utilize world leading French technology in ceramic matrix composites and world-class French technology in carbon/carbon. Up to 1500°C the preferable material is SEP's C/SiC (HERMES' shingles, control surfaces and winglets), but at higher temperatures Aerospatiale's carbon/carbon is necessary (nosecap and leading edge). The symposium included numerous papers on use, testing and NDE of these materials for HERMES and rocket nozzles.

Chemistry at the University of Liege, by LTCOL Chet Dymek, EOARD. (10pp) [EOARD LR-90-028]

Analytical and electrochemical research done by Dr. Bernard Gilbert is interesting because it emphasizes room temperature ionic liquids. He has done much excellent work, using both Raman spectroscopy and standard electrochemistry, on the chloroaluminate ionic liquids (melts) formed from $AlCl_3$ and MeEtImCl (methylethylimidazolium chloride). Significant results are in the identification of melt species, their structures and interactions, and the effect of solvents. Professor Jacques Collin is studying small molecules (N_2, H_2O, NO) in ionized and highly excited states, including NO^+ in highly excited vibrational levels, which are normally inaccessible because of Franck-Condon factors, by removing inner shell electrons. Work is also being done on what are called "halato telechelic polymers."

Polymer and Ceramics Research at Imperial Chemical Industries, by LTCOL Chet Dymek, EOARD. (17pp) [EOARD-LR-90-031]

The Imperial Chemical Industries facility at Runcorn, ICI Chemicals and Polymers Limited, houses the Research and Technology Department which conducts research and development in advanced ceramic and polymer materials. The polymer group presented recent results in three areas: (1) polyphenylene formation for structural or optoelectronic fibers, (2) polyphenylene for high pretilt layers for high-resolution liquid crystal displays, and (3) cross-linked terpolymers based on polyethyleneoxide for use in polymer electrolyte batteries and electrochromic displays. The ceramics research group presented results on the processing of ceramics and ceramic composites with enhanced fracture resistance resulting from internal flaw elimination. They also have expertise in metal matrix composites with surface treated ceramic fibers in which increased strength is because of enhanced bonding at fiber-matrix interfaces.

THE EMBASSIES: TECHNOLOGY ROUNDUP

Belgium

For further information on Belgian items, contact Ms. Patricia A. Haigh, Science Officer, U.S. Mission to the European Communities (USEC), 40 Blvd. du Regent, B-1000 Brussels, APO New York 09667-1030.

Proposed Combined Task Force on Biotechnology Research

On May 31, USDA Assistant Secretary Charles Hess met separately with Science and Research (DG XII) Deputy Director-General Hendrik Tent and with Mr. Marchini-Camia, to discuss terms of reference for the proposed task force on biotechnology research. Mr. Marchini-Camia is Chef de Cabinet for Fillipo-Maria Pandolfi, European Commissioner for Science, Research, Development, and Telecommunications.

The European Commission (Commission) prefers to characterize this joint biotechnological activity as an administrative arrangement rather than a more formal charter, which, according to Mr. Marchini-Camia, might require the Commission to seek member review and Research Council (Council) approval. In short, Pandolfi is eager to move forward with the task force as purely a Commission initiative.

The Commission also proposes to delete any reference to a termination date or other form of sunset clause in the terms of reference. Tent expressed Pandolfi's view that, at this level of exchange, it will be the general degree of interest on both sides that will drive decisions to continue to cooperate. In general, Pandolfi favors more general language in the terms which he feels would afford the opportunity for broader discussion of issues related to biotechnology.

Finally, Pandolfi re-emphasized that, if both sides agree, to include a comprehensive task force on science and technology (S&T), that this biotechnology group should be embodied under this broader relationship and be a model for other activities. He hopes, in fact, that the language in these terms of reference might be emulated in succeeding cooperative arrangements.

While it is clear that Pandolfi is intent on keeping this biotechnological cooperation at a level that can be initiated and managed by the Commission, the notion that future activities might take the same form does bear some thought. Pandolfi took a similar approach in recent discussions with Department of Energy Deputy Secretary Henson Moore concerning cooperation in fuel cycle assessments. In this meeting, Moore indicated that his principal concern is with the progress of the energy cooperation and that he sees no reason at this time for the joint activity to be defined or in any way constrained by negotiations toward a broader task force on S&T.

The tone of Pandolfi's discussions does seem to suggest that he is working toward a comprehensive administrative arrangement which would define our S&T relationship and which would include cooperative initiatives established within common parameters. This begins to sound less like a discussion group (through regular meetings to consider new initiatives would certainly be anticipated) and more like an umbrella Memorandum of Understanding. One distinction, however, is that Pandolfi apparently seeks this arrangement at a level that would not require Council approval.

Federal Republic of Germany

For further information on FRG items, contact Mr. Edward M. Malloy, Science Counselor, American Embassy, Bonn, APO New York 09080-7400.

Moscow's Future Goals in Space--Commercializing Space Technology

Recently, the Federal Republic of Germany's liberal-conservative daily newspaper *Frankfurter Allgemeine Zeitung* (FAZ) carried an article on the Soviet's space activities goals, referring to a paper by Michail Chernyshev, scientific observer at the Soviet APN press services *News from Science and Technology*. Chernyshev's paper focuses on transparency and economic benefits of Soviet space activities and reflects the objectives of the Soviet Central Research Institute of Mechanical Engineering, especially with regard to their commercialization. The research institute is responsible for Soviet space research and space policy. According to the FAZ article, the Soviets primarily strive for commercial profits through various remote-sensing satellites directed toward ecological and meteorological tasks.

In the past, primarily the meteor satellites have accomplished these earth-monitoring tasks which have proven their reliability for several generations. In the future, this satellite family will be supplemented by the advanced electro satellite which will have onboard TV cameras of higher performance. By 2000, the Soviets hope to increase profits through earth-monitoring satellites, such as the *Meteor-Priroda, Resource,* and *Ocean* satellites focusing on environmental problems.

In noncommercial space activities, the Soviets will promote basic research in astronomy, emphasize cosmic background radiation, investigate the correlations between sun and earth, investigate the extension of radio

waves within the ionosphere, and the construct advanced space observatories.

In interplanetary space flight projects, the Soviet Union dedicates its research activities to investigating Mars, with its first Mars flight planned for 2015 through 2017. However, based on U.S. calculations of the tremendous costs of a manned mission to Mars, Chernyshev doubts the value of such plans. Nevertheless, according to Chernyshev, the Soviets will continue to explore Mars with automatic space probes. They said they are prepared to cooperate with the U.S. in this field. In 1994, in the framework of the Mars '94 Project, the Soviets plan to launch two probes to investigate the Mars surface and atmosphere. The return to earth will be in 1998 with Martian rock samples aboard.

With respect to their moon program, Chernyshev states that the Soviets will neither launch their own moon probes nor install any moon bases at least through 2005. Nevertheless, they intend to cooperate with the U.S. by sending experimental devices aboard future U.S. satellites. After the initial phase of experimenting and testing the reliability of the *Buran* space vehicle, the Soviets will primarily focus on its utilization for manned and unmanned missions, even under commercial aspects. In space vehicle development with air-breathing propulsion systems, comparable to the design studies of the British *Hotol* and the German *Saenger Project*, Chernyshev says, the Soviet Union is also working on such design drafts, but they are still in early stages.

In the future, the Soviets will emphasize space technology spin-off for their own industry. In the framework of the Soviet reconversion program, it is now possible to apply space technologies to products for the domestic, as well as for the international market. According to Chernyshev, the Soviet Ministry for Mechanical Engineering has made more than 700 different products, machines, and facilities of the space industry available to the manufacturing and consumer products industry.

Two New Particle Accelerators Begin Operating

Recently, the Society of Heavy Ion Research (Gesellschaft Fuer Schwerionenforschung [GSI]) in Darmstadt/Hesse, one of the Federal Republic of Germany's 13 national large-scale research centers, began operation of two newly installed particle accelerators: the Heavy Ion Synchrotron (SIS) and the Experimental Storage Ring (ESR).

Both facilities are interconnected with the basic linear accelerator, UNILAC, which has been operating since 1975. The interconnected arrangement and performance of all three facilities is unique. At a length of 120m, the UNILAC is capable of accelerating ions of all chemical elements, including uranium, to an energy of 20 megaelectronvolts (MEV) per nucleus, corresponding to about 20 percent of velocity of light (60,000km/s). The UNILAC facility can be used either for independent experimental programs or as a preaccelerator for the SIS and ESR facilities.

The SIS consists of a ring of 216-m circumference (68.5-m diameter). Capable of accelerating heavy ions, including uranium, to an energy of 1-2 gigaelectronvolts (GEV) per nucleus, the capacity of SIS exceeds that of UNILAC by a hundredfold. From SIS, the nuclei can be extracted out of the acceleration ring and diverted into either a laboratory for further experiments or into the ESR facility. The ESR has half the circumference of SIS.

With the unique interconnection of all three facilities, the GSI accelerator system provides for a variety of advanced physical, chemical, and biological experiments. More than 100 experiments have already been proposed. An international scientific committee will select the experiments with respect to their scientific quality.

Experiments with particle radiation of radioactive isotopes will be conducted to achieve improved knowledge about the behavior of nuclear matters under extreme conditions. Generation of highly densified matter through heavy ion radiation points to energy generation via nuclear fusion. Heavy ion radiation will also be used for reliability tests of electronic components used in space, as well as for experiments on radiation protection at manned space flights. In the biomedical area, heavy ion radiation is used for therapy of localized cancer tumors. Experiments in this field will be carried out at GSI in cooperation with the German Cancer Research Institute in Heidelberg and the university clinics of Heidelberg.

France

For further information on French items, contact Dr. Michael Michaud, Science Counselor, American Embassy, Paris, APO New York 09777.

French Ocean Research Institute

Institut Francais de Recherche pour l'Exploitation de la Mer, Centre Océanologique de Bretagne (French Institute of Research into the Exploitation of the Sea, Brittany Oceanology Centre) is a French public sector agency. Founded in 1984, the purpose of the institute, commonly known as IFREMER, is to conduct fundamental and applied research and to develop technologies related to exploring and using the ocean. The IFREMER operates under the joint supervision of the Ministry for Research and Technology and the Ministry for the Sea. The government provides most of IFREMER's budget of about F850 million (about $150 million), but IFREMER also brings in money itself (about F150 million [about $26 million]) through services, product sales, contracts, investment participation by other organizations, and bank loans.

The IFREMER has a staff of about 1,200, and has centers at Boulogne, Brest, Nantes, Toulon, and Tahiti, plus smaller installations at Martinique, St. Pierre et Miquelon, and New Caledonia. The organization has 10 ships, including 4 ocean-going general oceanographic vessels, 1 ocean-going support vessel, 2 cold region and high sea fishing vessels, 2 coastal fishing vessels, and a coastal oceanographic vessel. The IFREMER also has two manned submersibles--Nautile (6,000m) and Cyana (3,000m), plus five unmanned submersibles and robots.

The IFREMER's 1989-1993 plan calls for the following policy orientations:

- Give priority to marine resources and their management
- Increase scientific and technical data transfer to professional bodies
- Reinforce relations with various partners
- Develop regional program bases
- Consider the reality of Europe
- Extend international activity
- Fix a development objective for own funds.

IFREMER identified five priority "axes" of action:

1. Utilize products of the sea, including research to improve the quality at each stage of production, and use new conservation processes

2. Cooperate with other French agencies geosphere and biosphere through program of the International Council of Scientific Unions

3. Emphasize coastal waters and ecosystems through environmental surveillance, knowledge, and protection

4. Accomplish deep-sea research with undersea robot

5. Renewing IFREMER fleet, by putting into service a new research ship, L'Atlante, launched in December 1989.

The IFREMER has three main divisions: living resources, engineering and technology, and environment and ocean research. There also are divisions for economic relations and cooperation, naval means, and computers.

Living Resources

- Fish resources - evaluate new resources, improve small-scale fishing, and study stock recruitment variability
- Aquaculture - mollusks, fish, and crustaceans breeding projects
- Economic studies - fishing control, develop small-scale fishing fleets, and marine culture economy
- Product promotion - improve storage and processing technologies; extract and promote fish proteins; high-value substances from fish (great

demand in the pharmaceutical and agrofoodstuff industries); and new structures for exchanges among research, industrial, and professional bodies
- Control and monitor resources - sanitary quality control.

Engineering and Technology

- Undersea activities - develop manned submersibles and unmanned scientific vehicles; e.g., SAGA-1, highly autonomous submersible
- Ocean mining engineering - work on polymetallic nodules
- Offshore installation behavior - basic technologies to design, construct, monitor, and repair offshore facilities
- Naval technology - study new fishing boats
- Fishery and marine culture engineering - perfection of tools, equipment, and instruments for fisheries and marine cultivators
- Instruments - new sensors.

Environment and Ocean Research

- Coastal environment studies - coastal ecosystems pollution and disturbances
- Remote sensing applications - imagery from spot satellites
- Physical oceanography - participate in world climate research program
- Marine geosciences - participate in ocean drilling program and in French-American FARA project on Atlantic rift
- Deep-sea environment and biotechnologies - study hydrothermal ecosystem micro-organisms.

The IFREMER has extensive cooperative relationships with multilateral and national ocean research programs. The organization participates in the European Community program Marine Science and Technology (MAST) and the European Research Coordination Agency (EUREKA) program EUROMAR, as well as in such multilateral efforts as the Intergovernmental Oceanographic Commission and the International Commission for the Scientific Exploration of the Mediterranean Sea. Bilaterally, IFREMER cooperates with institutions in the Federal Republic of Germany, Norway, the Netherlands, Finland, Spain, Portugal, Italy, the U.S.S.R., Japan, and Peoples Republic of China. With the U.S., IFREMER has cooperative relationships with the National Oceanic and Atmospheric Administration and the National Science Foundation.

The President-Director General of IFREMER is Pierre Papon. The organization's headquarters address is 66 Avenue D'Iena, 75116 Paris, France. Telephone: (33)(1) 47-23-55-28; FAX: (33)(1) 47-23-02-79.

French Polar Research

The French government will soon take the first steps toward implementing steps of recommendations (approved by the Council of Ministers in February 1990) designed to strengthen French research in Polar regions. The recommendations were first proposed in a report by Claude Frejacques, President of the Consultative Committee for French Southern and Antarctic Territories, and by Frederic Thiriez, Director of Political, Administrative, and Financial Affairs for Overseas Territories. The report criticized the lack of coordination and direction of French Arctic research, and proposed a new, unified organizational structure to guide research in both the Arctic and Antarctic regions.

At present, France operates a small Arctic base at Spitzbergen. Antarctic activities are concentrated at the Dumont-D'Urville Coastal Base, located 2600 km south of Tasmania. In 1989, the French government allocated a total of F110 million ($20 million) for polar research, which is, according to the French report, about half of the amount currently spent on polar research by the U.K. or Federal Republic of Germany individually.

On the basis of the Frejacques/Thiriez recommendations, which were endorsed by the Ministry of Research and Technology and the Ministry of Overseas Departments and Territories, three new organizations will be formed:

1. Interministerial Committee on polar research - will set overall policy directions and authorize major budgetary decisions

2. Polar Environment Committee - will monitor the environmental impact of research activities under the direction of an independent chairman

3. Institute for Polar Research/Paul-Emile Victor expeditions - responsible for logistics and program coordination; will be set up to eventually attract private funds.

A recent European Community Council of Ministers meeting also gave the go-ahead to construct a new French Antarctic base at a site known as Dome C. Located 900 km from the open ocean at approximately 124° E, 74° S, and at an altitude of 3,250 m, Dome C will be one of three manned research stations operating in the interior of the Antarctic Continent. The other two are Amundson-Scott (U.S.) and Vostok (U.S.S.R.). There is already a functioning automated meteorological station at Dome C, as well as the vestiges of an American camp used in 1987 glaciological studies.

The new French base will be supplied out of Dumont-D'Urville, about 1,000-km distant, where an air strip is due to be completed during the Antarctic summer of 1991-1992. Air transport between Dumont-D'Urville and Dome C will be by light aircraft equipped with skis and wheels. Heavy, nonfragile equipment and supplies will be dropped from cargo planes by parachute. Surface transportation by tractortread vehicles, while slow (20 days if the weather is good), will be necessary to move fuel and delicate, but bulky, items, and to remove wastes. Construction of the base will cost an estimated F50 million ($9 million), and, if all goes according to plan, will be completed by November 1994.

A report completed earlier this year by Bernard Morlet, Head of the Research Mission for French Southern and Antarctic Territories, identified four major categories of research to be conducted at Dome C:

1. Atmosphere-Ice System - low-level wind profiles, radiation budget measurements, deep ice cores for paleoclimatological studies, physics and chemistry of the troposphere, stratospheric physics, and chemistry (Dome C is directly beneath the seasonal "hole" in the ozone layer)

2. Solid earth sciences - seismological measurements, electromagnetic imagery of the upper mantle, development of measurement systems under climatic extremes (potentially useful for eventual studies of Mars)

3. Astronomy and upper atmospheric studies - solar seismology, collection and study of micrometeorites, electrodynamic investigations of the ionosphere/magnetosphere system

4. Human biology and medicine - studies of psychological and social adaptation of small isolated groups under extreme conditions, adaptation to cold, chronobiology.

Indonesia

For further information on Indonesian items, contact Jeffrey T. Lutz, Science Attache, Medan Merdeka Selatan 5, APO San Francisco 96356.

Seminar on Financing of Nuclear Power Projects in Developing Countries

Introduction. The International Atomic Energy Agency (IAEA) Topical Seminar on Financing of Nuclear Power Projects in Developing Countries will be held in cooperation with the Indonesian National Atomic Energy Agency (BATAN) September 4-7, 1990, at the Kartika Chandra Hotel, Jakarta, Indonesia.

Background. Following is background information (based on IAEA-SR-156) on the IAEA topical seminar on financing of nuclear power projects in developing countries.

Purpose. The purpose of this seminar is to provide an opportunity for discussion among different partners involved in the cost evaluation and financial planning of nuclear power projects; i.e., the buyer utilities, the manufacturers, the various national export/credit agencies, the commercial banks and the international or regional banks, and government agencies. The discussions will focus on:

- Factors influencing nuclear power investment costs, and in particular ways and means to control and reduce costs

- Particular problems and constraints on financing nuclear power projects in developing countries (local and foreign financing)

- Possible ways and means to alleviate financing problems: private versus public ownership, technical means (plant standardization, SMPRs, modular reactors), localizing manufacture versus importing, type of contracts

- Suitability of current financing mechanisms: OECD consensus, local financing, foreign financing

- Possible new arrangements for financing nuclear projects in developing countries.

Topics. Participants are invited to focus their papers and discussions on the following major topics related to the financing of nuclear power projects in developing countries:

1. Perspective of Nuclear Generation Costs

- Review of evolution of nuclear power investment costs and fuel cycle costs

- Comparison of generation costs for nuclear and alternative power sources

- Methodologies for evaluating generating costs of power projects

- Ways to reduce and control nuclear power plant costs and schedules; e.g., standardization, modular designs, localization.

2. Assessment of Problems and Constraints for Financing of Nuclear Power Projects

- General problems of financing projects in developing countries, factors influencing financial capabilities of a country

- Particular problems and constraints on financing nuclear power projects in developing countries; e.g., large investment, long construction times, public/political acceptance

- Positive and negative impacts of environmental concerns; e.g., nuclear safety, global warming, acid rain, on power project financing

- Review of financial risk factors and analysis methodologies from the points of view of international/national bankers, credit insurers, buyer utilities, and suppliers. Project financial risk as a constraint on availability of financing for nuclear power projects in developing countries

- Measures for reducing project financial risk as a means to improve the overall climate for nuclear power financing.

3. Mechanisms for Financing Nuclear Power Projects In Developing Countries

- Review of experience with various financing schemes

- Lessons learned from international investment approaches

- Different forms of project ownership; e.g., private versus public, joint ventures, and the influence on financing

- Review of experience and possible role of build-own-operate-transfer schemes for project financing (from viewpoint of potential buyers, suppliers, and financing institutions)

- Discussions on other possible and innovative financing approaches to be envisaged and the role of international organizations.

Participation. The seminar is expected to interest experts in:

- Evaluation of investment and generation costs of power projects, and, in particular, for nuclear projects

- Economic and financial planning of electricity generation system expansion

- Financial risk assessments for large projects, in particular, energy projects in developing countries

- Managing large projects in developing countries.

These experts are expected to belong to government agencies; energy and finance ministries; national planning organizations; electric utilities; national export-credit agencies; national export/credit insurance agencies; large commercial banks; international or regional banks; energy, electricity, and economic planning institutes; nuclear manufacturing companies.

Comments

The timing of the IAEA Topical Seminar is significant because the government of Indonesia recently issued terms of reference for a feasibility study for the first nuclear power plant at Muria Peninsula Region (on the Island of Java). The feasibility study consists of two parts: feasibility study on techno-economic and safety aspects and study on siting and environment. The first study will take 2 years; whereas, the second will start in parallel with the first and should be completed in 4 1/2 years. The working languages of the meeting will be English, French, Russian, and Spanish. All communications, synopses, and papers must be sent to IAEA in one of these languages. Contact IAEA at: International Atomic Energy Agency, Vienna International Centre, Wagramerstrasse 5, Postfach 100, A-1400 Vienna, Austria; Telephone: 222-2360; Cable: INATOM VIENNA; FAX 222-234564; Telex: 1 2645.

Italy

For further information on Italian items, contact Reno Harnish, Office of Science Counselor, American Embassy, Rome, APO New York 09794-9500.

Italians Prepare to Relinquish EUREKA Chairmanship

Under the chairmanship of Antonio Ruberti, the Italian Minister for Universities, Research, Science, and Technology (MURST), the Italians developed some limited new initiatives. In the environmental area under the umbrella of the EUROENVIRON project, (EUREKA-sponsored) they have pushed forward the ENVINET project for cooperation in environmental monitoring. Preliminary efforts in this program call for the establishment of a standardized database among the EUREKA members to study and monitor air and sea pollution, acid rain, fire, and earthquake threats. The Italians expect more than 40 separate projects to result from the initiative. The program provides for cooperative efforts among government organizations, universities, and the private sector in formulating the database. Italian organizations already involved include several universities, the National Research Council (CNR), the Italian Committee for Nuclear Energy and Alternative Energy Sources (ENEA), the National Physics Institute of Italy (INFN), and Aeritalia, Fiat, and Fiar.

Additional projects that were proposed at the beginning of the Italian chairmanship have included a project to establish a European standard for high-definition television (HDTV), FAMOS an umbrella project with substantial Italian participation to study automated factories, and JESSI an 8-year joint European silicon submicron development project with an ECU 3.8-billion budget.

Within the organizational area, the Italians have strongly supported efforts to more closely coordinate the activities of the EUREKA program, particularly identifying new projects. Italy has pressured to increase the meeting frequency to coordinate project planning. Italian press reports in mid-May gave Italy a lot of credit for an initiative to organize interparliamentary conferences before the annual ministerial conference to discuss and review EUREKA project proposals. In fact, such conferences have largely arisen out of French and German proposals. The Italian side has also pressured for additional efforts to explore programs of technologies that could include the participation of developing countries.

The potential for involvement of Eastern European countries in the EUREKA project has become a major issue during the past year. The EUREKA has not come to terms with a means to expand European involvement in EUREKA. To date, as nonmembers of EUREKA, Eastern Bloc countries participation has been limited because nonmembers generally can only participate through the subcontract activities of private firms or organizations in those countries. This has been a roadblock in the participation of the still largely centralized economies of Eastern Europe. The Italian side is seeking to define means to bend the existing rules to allow more Eastern participation. The Italian government does not foresee actual Eastern Country membership in EUREKA in the near future. The Italians prefer, at least for the time being, to concentrate on liberalizing the existing structure of the project to allow expanded Eastern participation.

The picture for U.S. participation in EUREKA has not improved noticeably during the Italian chairmanship. There was some talk that the Italians would support an expansion of U.S. participation in EUREKA. The program continues to be intended primarily as a European response to the U.S. SDI programs, and Japan's human frontiers initiative, and that the only possibility for U.S. participation is through subcontract efforts with participating European organizations.

Artificial Heart Research

A program on innovating and developing cardiac technologies (ICAROS) began in 1986 and is a cooperative agreement between the Italian National Research Council (CNR) and Fiat. With additional support from the National Program on Cardiac Technologies the program is costing 220 billion lire. Through its company, Sorin Biomedica, Fiat contributes 25 percent.

The program was recently reviewed in Rome. So far, it has produced highly efficient cardiac valves manufactured with an innovative process that makes them physiologically biocompatible to the user. About 75,000 valves have been implanted into patients with no malfunctioning or breaking reported. The project has also manufactured a temporary mechanical heart to be used by patients waiting for a transplant. Ten of these temporary hearts have been applied to as many patients awaiting for heart transplants; seven survived.

The final aim of the program is to manufacture an entirely artificial heart. A prototype should be ready in 5 or 6 years. In the meantime, Sorin Biomedica has patented a new type of bileaflet cardiac valve that operates with two mobile elements that open and close simulating the movement of a butterfly's wings. The new bileaflet valve facilitates the passage of the blood flux and is at the present, entering the phase of direct implanting in patients.

Italians Isolate Human Gene with Possible Use in Cancer Therapy

Professor Francesco Blasi has announced the isolation of a human gene that acts as a receptor for the enzyme urokinase and that might be useful for future cancer therapy. Professor Blasi heads two research teams at the Naples Institute and at the Copenhagen Institute of Microbiology, respectively. The two teams, with the sup-

port of a third team headed by Danish Professor Dano, have been jointly conducting advanced research on extracellular proteolysis to study a system of biochemical reactions responsible for cell migration within the organism.

During this research, a protein was isolated that acts as a receptor for urokinase. The urokinase is fixed on the membrane of the cell through the receptor. The enzyme urokinase activates the plasminogen forming a molecule essential to determine the migration of the cell within the organism. This procedure occurs during cell migration in metastases processes, hence by blocking urokinase activity by acting on its newly discovered receptor, the metastases process could theoretically be controlled.

To date, the blocking process has been tested on mice and tumoral formation was reduced. However, according to Professor Blasi, they will not test on humans soon because of deleterious side effects that might be induced by the blocking of urokinase.

Italian S&T Cooperation with Eastern Europe

According to an Italian Ministry of Foreign Affairs (MFA) source, Italy is trying to focus its science and technology (S&T) relationship with the East through Foreign Minister De Michelis' five-country (Italy, Austria, Yugoslavia, Hungary, and Czechoslovakia) initiative. A cooperative S&T program is to be ready sometime this summer. Our source said that the proposals will focus on building up the scientific organization of the Eastern countries and helping them to obtain appropriate low and medium technology for economic development. The aim is to help the Eastern European countries move closer to the West and takes advantage of relations that were strong until World War II.

To the greatest extent possible, the MFA will try to use multilateral European institutions to build its ties with the countries of the five-party initiative. For example, through the European Space Agency and the Italian Space Agency, the Eastern countries could learn how to use satellite images for weather forecasting and disaster control. The Eastern countries would also be pulled into EUREKA research programs. Italy's National Institute of Physics (INFN) will help pull the partners into using the physics laboratories at CERN and Trieste. The Italian effort is being coordinated closely with the European Community (EC) so that the five-party cooperation melds with later EC projects.

Italy will also try to help the three Eastern neighbors with nuclear safety issues. This effort is being led by the Alternative and Nuclear Energy Agency (ENEA) which still has an enormous pool of expertise despite the referenda which ended the nuclear power program in Italy.

Our contact at the Universities and Scientific Research (MURST) described Italian cooperation with Eastern Europe as quite small. According to this source,

Italy has only begun to reassess cooperation with the East following the political restructuring in the region. Cooperation has been limited to basic research implemented primarily through the exchange of experts, workshops, and symposia funded by each participating country. Primary areas of research have included mathematics, physics, chemistry, social science, and some electronics. The MURST requested for its 1991 budget a small amount for fellowships to be granted to Eastern European scientists for study in Italy. These will be granted strictly on a reciprocal basis.

Companies are largely free to press ahead with new initiatives as long as they do not violate existing laws on technology transfer. Our MURST contact was of the impression that the private sector was moving more quickly than the government to increase technological cooperation.

The CNR told us that its cooperation with East European academies of science was accomplished through bilateral agreements signed in the mid to late 1970s. These agreements are woefully underfunded with expenditures of about $150,000 apiece in 1989. The CNR's innovation held a seminar in Poland during the last week in May with the Academy of Sciences to facilitate further contacts. The seminar is a pilot for further seminars in the other East European countries that underwent political change in 1989.

Italian R&D Decline versus GNP

The report on Trends and Data of the Science and Technology in Italy which was an annual endeavour of the Italian National Research Council (CNR) has been discontinued. Under legislation, the Ministry of University and Scientific Research (MURST) must prepare every 3 years a comprehensive report similar to the one that CNR prepared. Eventually, the MURST must issue a report similar to one that the Embassy has analyzed and reported annually over the past years.

1989 - Research Expenditure Estimate
$1 = 1250 lire
lire (billions), $ (millions)

Total Expenditure	16,360	13,000	100
Public Sector	3,792	6,200	47.6
Private Sector	8,560	6,800	52.4
Universities	2,889	2,311	
CNR	993	793	
ENEA	845	675	
INFN	283	116	
ASI	742	593	
Inst. of Health	94	75	
ISTAT	175	14	
Min. of Agriculture	69	55	
Min. of Cult. Assets	80	64	
Min. of Defense	594	475	
Min. for the South	429	343	
Min. of Health	82	66	
Min. of Transportation	84	67	
Other Ministries	70	56	
Intl. Contributions	201	160	
Regional Admin. and Others	162	131	
Total	7,792	6,614	

Italy - Short Technology Items

The Italian Minister of Scientific Research inaugurated the first computer network for scientific research capable of connecting in real time all of the most important Italian research institutes and to interact also with foreign networks. The Italian network called GARR (Gruppo Armonizzazione Reti Della Ricerca - Standardization Group for Research Networks) is one of the most advanced of this type providing connections at the speed of 2 megabits/sec and was built for about 5 billion lire (about $4 million) provided by the Ministry of University and Scientific Research.

The Italian Parliament will enlarge and complete the underground physics laboratory at Gran Sasso costing 160 billion lire (about $128 million). The financing will build two underground halls for experiments and a tunnel for services. The Italian Committee for Industrial Policy (CIPI) authorized spending 633.2 billion lire (about $500 million) for national research projects on advanced materials (441.8 billion lire), chemistry (176.6 billion lire), and advanced training for biotechnology (14.8 billion lire).

In the National Research Council Laboratory of Ionized Gases in Padua, experiments on cold fusion continue in cooperation with the Padua University and the National Institute of Nuclear Physics. According to Professor Malesani, Director of the Ionized Gases Laboratory, tritium was found several times in the electrolytic cells; however, the experiment is not always reproducible.

R&D Allocation in the 1990 Government Budget Law. The 1990 Government Financing Law assigns 9,110 billion lire (about $7.28 billion) to the Ministry of University and Scientific Research. Of this total, the National Research Council (CNR) will receive for 1990 1,030 billion lire (about $820 million), 1,080 lire for 1991, and 1,110 lire for 1992.

University of Milan, CERN, and Livermore Cooperate in High-Energy Physics. The LASA Laboratory of the University of Milan is starting the project Electron Laser Facility for Acceleration (ELFA) in cooperating with CERN, Los Alamos National Laboratory, New Mexico, and Lawrence Livermore National Laboratory (LLNL), California. The Italian National Institute for Nuclear Physics is financing the project for the next 5 years with 12 billion lire (about $10 million). The aim of the ELFA project is to obtain, with a relatively modest budget, the first electronic cannon in Europe with 400-amp peak current and with a high power (100 kW) laser. The LASA Laboratory is contributing in the development of the research carried out by the LLNL, through a free electron laser (FEL) at high light intensity with high current and short impulses (6 cm in EFLA) produced by radiofrequency linear accelerators (LINAC).

Ministry of Industry Funds for Technological Innovation from 1982 through 1989. The Italian Ministry of Industry published some data on the financing of private industry for technological innovation with government funds provided by Law 46 of 1982. From 1982 through 1989, the financing of technological innovation projects was extended to 1,516 cases for a total government commitment of 4,632 billion lire (about $4 million). Electronics projects are the most numerous 633, followed by the chemical industry with 318 projects, automobile industry 227, aeronautics 27, steel and iron 22, motorcycle 13, food and agriculture industry 52, and others 224. The government financing for these projects range from a minimum of 35 percent of the whole cost to a maximum of 55 percent with exceptions that reach 70 percent for industry located in less advanced areas of the south. The financing is given through easy terms loans reimbursable by industry in 15 years or through funds that are not recuperated.

New Product for Paper Recycling. The Montefluos Company of the Montedison-Ferruzzi Group is marketing a new product called "Alvaran" which alone may replace many traditional surfactants (surface active substances) employed to remove ink in paper to be recycled. Alvaran is being tested at Montefluos in a small plant treating about 10kg/day of paper to be recycled. Alvaran is added directly in the pulper, together with peroxided water then the separation of ink occurs through flotation. Montefluos sells Alvaran in Italy and several paper mills have adopted this product with an output of recycled paper of 90 percent.

New Leukemia Drug. The research laboratory of the Farmitalia-Carlo Erba Pharmaceutical Company of the Montedison-Ferruzzi Group located in Nerviano near Milan has synthesized a chemical called "Idarubicina" which is an anthracycline belonging to the group of antitumoral antibiotics. The new drug is very effective against leukemia and lymphomas with results from five to ten times higher than those obtained with drugs traditionally employed for these diseases, and with substantially lower or downright negligible side effects. The Idarubicina substance was tested for a long time in several therapeutic centers in Italy and elsewhere in Europe. The substances was also tested in the U.S. at the Adria Laboratories of Wilmington, Ohio, which are associated to Farmitalia-Carlo Erba. Idarubicina is presently being marketed in Italy under the commercial name of "Zavedos."

European Community Selects Genoa for High-Temperature Superconductivity Research Coordination. The European Community has selected the City of Genoa to be the Center for the Coordination on High-Temperature Superconductivity Research, with the participation of laboratories from Italy, France, Great Britain, Federal Republic of Germany, Belgium, and Switzerland. Re-

search will especially focus on methods to increase the current density transported by a surface unit. Each laboratory will develop the areas in which it is already more advanced: the centers of Karlsruhe, Geneva, Cinisello Balsamo, and London will develop cables; Genoa and Grenoble will study the property of the current transportation; Parma, Rome, and Genoa will study SSC physical chemical properties. The various findings will be integrated through the Genoa coordination point. The operation of the network for exchange and comparison of information and data is estimated to cost from 500 to 800 million lire per year.

Italy is Assigned the Construction of the "EUROPA" Space Sail. Italy was assigned, during the Montreux Space Commerce 90, the construction of the "EUROPA" space sail which, with the Asian and American space sails, will participate in the Columbus Space Sail Cup of 1992. Aeritalia will build the space sail, but the project was supported and studied by other industries and by seven Italian universities. The project is estimated to cost 30 billion lire (about $24 million) and is made up of a 294kg heavy hull and by a 126kg heavy square sail 100m long.

Space Capsule Built by Aeritalia. The Italian Space Agency (ASI) approved a contract with Aeritalia to build "CARINA" (Capsula Di Rientro non Abitata - Unmanned Re-Entry Capsule) also called the Space Taxi. The reusable capsule, weighing from 500 to 650kg will bring into orbit scientific payloads weighing 150kg to carry out microgravity experiments for a maximum duration of 20 days at an altitude of 300 to 400km. The launch of CARINA will take place in 1992 with the rocket San Marco Scout from the Italian range San Marco in Kenya. The contract between ASI and Aeritalia is estimated to reach a value of 7 billion lire (about $5.6 million).

Coordination of Astronomical and Astrophysical Research. During a recent meeting of the Italian Astronomical Society (SAIT), the creation of a National Institute of Astronomy and Astrophysics (INDAA) was announced. The INDAA is expected to coordinate research among the 12 Italian astronomical observatories, the several astronomical and astrophysical university institutes, and the Institutes of Cosmic and Atmospheric Physics belonging to CNR and the National Space Agency. The new institute is supported by the Minister of University and Scientific Research and is expected to start operating in the fall. Professor Vittorio Castellani, President of SAIT, announced also the cooperation with the Soviet Union for a 1.70-m diameter ultraviolet space telescope expected to be launched in 1995.

Safety in Fires with New Plastics. The Institute of Chemistry and Technology of Polymers of CNR located in Catania is patenting a new type of plastic without fire risk and with no health hazards. The polymer material tested in Catania does not burn when it contacts a flame, but it inflates and acts as a fire extinguisher. The new material also has the advantage of suppressing smoke made of carbon monoxide and hydrochloric and hydrocyanic acids, which are released by plastic treated with traditional flame retardant chemicals.

Environmental Watch - Short Environmental News Items

Innovation. The Italian Interministerial Committee for Industrial Programming has approved soft loans or full financing without repayment to industry. The money is for innovative environmental projects concerning

- Decreased use of raw materials
- Decreased polluting emissions
- Manufacturing less polluting and more recyclable products
- Creating innovative devices to recycle solid, liquid, and gaseous waste.

Water Lacking. According to a study presented by the Chamber of Deputies, 15 million Italians receive drinking water only 2 days per week. Another 30 million are having problems related to the quantity and quality of drinking water received. The Parliament is preparing a law to create a water supply company with a managerial cost/profit program that should, in 5 years, improve the status of drinking water distribution and limit the annual cost increase.

Hazardous Waste. The Ministry of University and Scientific Research, jointly with the Ministry of Environment, made available 19.8 billion lire (about $16 million) for research projects aimed at improving operation of incinerators for hazardous waste and for purifying and handling agriculture waste.

Acid Rain. The Department of Forestry of the Ministry of Agriculture says that acid rain is responsible for the deterioration of 17.3 percent of the woodland area in Italy. This compares to a 1986 figure of 5.8 percent. Twenty-six percent of wood plants weakened by atmospheric pollution are reported to be attacked by diseases.

Green Firms. A recent survey conducted in Italy revealed that there are 3,000 environmental industries employing 30,000 individuals with annual sales of 4,000 billion lire (about $3.2 billion). The number of industries and their business turnover increased an average of 70 percent from 1986 through 1989 and is located (50 percent) mainly in Northern Italy. The average environmental industry is of small/medium size employing 50 individuals.

Pollution in Adriatic Sea. The Director of the Italian Institute for Research on Waters announced that the

mucilage that caused so much damage in the Adriatic Sea is filaments made up of polysaccharides. As such, they are not hazardous to human health. When they decompose, they do not subtract oxygen from the sea, therefore do not cause death of fish. However, they tend to catch fish eggs and larvae, thus indirectly contribute to a sea fauna decrease.

Italian Bill to Clean Up Atmosphere from Sulphur and Nitrogen Oxides. When Italy finally completes implementing EEC standards by 2000, clean air, free from sulphur and nitrogen oxides, will be obtained, but it will be expensive. During a recent meeting of environmental economists organized by the Italian National Hydrocarbons Agency, the University of Venice, and the EC, it was estimated that Italy will have to pay 761 billion lire (about $613 million) to implement EC directives. Italy's bill is high because, in contrast to France, the Federal Republic of Germany, and Great Britain, it has no national law providing protection against the emission of sulphur and nitrogen oxides. Therefore, the gap must close from zero.

Italian Company Wins First Prize in Environmental Competition. The Italian company, Retiflex, won first prize in the EC competition *Industry and Environment* for creating an environmental product. Part of the Montedison Ferruzzi Group, Retiflex has devised a polypropilene product that replaces asbestos mainly in the building industry. In Italy, only 60,000 tons of asbestos are employed every year in the building industry. In Western Europe, using asbestos for the same scope reaches a total of 230,000 tons. Retiflex was selected after separate national and EC screenings. About 900 companies presented their environmental products.

Italian Ministry of Health Organizes Continuous Monitoring of Coastal Seas. Between May 31 and September 30, the Ministry of Health will collect data in all the seas surrounding the Italian Peninsula concerning their safety for swimming. The local health units have been instructed to sample sea water twice per month at 2-km intervals along the seashores and in several points out at sea. The data will be regularly transmitted to the Ministry of Health which will publish a bulletin twice monthly and will activate and maintain a telephone service for public inquiries. The monitoring is also extended to those lakes and rivers that are popular with swimmers.

In a tryout test conducted in April, the Adriatic Sea was revealed to be 100 percent safe despite its algae problem. The same may be said for the seas surrounding the region of Calabria, while in Latium (Rome region) and Tuscany, the safety decreases to 95 percent (not further defined) to touch an all time low in Sicily with 78 percent of safety. At present, the average safety for the Italian Coastal Sea is estimated to be 92 percent. However, environmental organizations are objecting to these

data by stating that the local health units would limit their samples in environmentally risky spots to a maximum of 10 tests. They should instead take more samples from waters considered reasonably safe so that an acceptable average may be calculated. The Ministry has retorted that in the last monitoring campaign, the sampling sites were 3,833 and only in 65 of these points were the number of tests restricted to 10. These were mostly confined to waters surrounding small islands off the coast of Sicily.

Tons of Ammonia Over Italy. The Italian National Research Council Institute for Study on Atmospheric Pollution carried out a study to determine the quantity of ammonia present in the atmosphere. The study was done jointly with EC member countries and seven other European countries. In Italy, it was estimated that 101,000 tons of ammonia is emitted in the atmosphere annually through using agricultural fertilizers. An additional 252,000 tons are emitted by the dumping from animal farms and 6,000 tons are emitted by industry. The large presence of ammonia in the atmosphere is responsible for forest damage, and is also suspected to influence the abnormal growth of algae in the Adriatic Sea.

European Environmental Center to be Located in Rome. The World Health Organization (WHO) has accepted the proposal of the Italian Ministers of Health and of the Environment to establish in Rome at the beginning of 1991, the European Center for Environment and Health (Center). The purpose is to create an integrated information system for environmental and health data covering 32 European countries. The Center will operate as a technical scientific structure of the European WHO office for all aspects of environmental health and will contribute to implementing a prevention strategy to be shared by all participating European countries.

Fiat to Produce Heat and Electricity with Waste. Fiat has announced a program intended to reuse industrial waste to produce heat and electricity. The new system called "Sistema Fenice" will use the most updated and technologically advanced methods for recycling industrial waste. The system is expected to cost 300 billion lire (about $240 million) and its routine operation is expected to cost an annual 70 billion lire. The system can handle 200,000 tons of waste annually. Inert material produced by the system will be buried in dumping grounds and later covered with earth and vegetation. The system is also expected eventually to handle that portion of Fiat waste that remains untreated. Fiat hopes to totally obliterate waste produced by its industrial cycle. Sistema Fenice will be a part of the Fiat overall environmental effort for which Fiat has allocated 1,500 billion lire (about $1.2 billion) for the 1990-1993 period, plus 1,200 billion lire to solve automobile gas emissions problem by 1993.

Hazardous Waste Repatriated from Illegal Dumps in Developing Countries is Still Untreated. Three years ago, the scandal of hazardous waste illegally exported from Italy to dumps in developing countries forced the Italian government to make 600 billion lire (about $480 million) available for the disposal of the industrial hazardous waste being repatriated. However, according to the President of the Association of the Environmental Departments of Local Administrations, almost nothing was spent to solve the problem and the barrels with dangerous waste are still stocked on docks and warehouses.

In some cases, they are still kept aboard the ships. The whole cargo of the *Karen B* is still stocked untreated in several towns of the Emilia-Romagna region in places monitored by TV cameras and sensors and apparently jell protected, but still untouched from the day of their arrival. The hazardous waste unloaded a couple of years ago from the *Jolly Rosso* is still docked in the port of La Spezia. The other cargo ship, *Deep Sea Carrier*, is still anchored with all her cargo aboard in the Port of Leghorn. Only about 2,000 out of the 10,800 barrels full of dangerous and health hazardous waste unloaded from the *Zanobia* been treated and disposed of.

Environmental Minister Ruffolo replied to these accusations by stating that the waste in question is being treated partly in French plants and partly is waiting to be treated in a plant under construction in Italy. Some of the waste, according to the Minister, is not hazardous and therefore will be interred with special precautions in dumping places in the region of Emilia-Romagna. Finally, the Minister said that 160 billion lire already have been spent to handle this repatriated waste, resulting in constructing special stocking facilities in the ports of Leghorn and La Spezia. Dumping places have been created for nonhazardous waste, constructing disposal plants for health hazardous waste, and research for new methods and processes to identify, handle, and treat these wastes.

Italy Technology Roundup - Short Technology Items

Gallium Arsenide Crystal. Two researchers of the National Research Council Institute for Special Materials for Electronics and Magnetism have patented a method for the automated synthesis and growth of gallium arsenide monocrystals. With this method, gallium arsenide crystals were created of 1, 2, and 3 inches in diameter weighing from 0.5 to 3 kg.

Photovoltaic Energy. The Italian National Agency for Nuclear and Renewable Energies is building a 1-MW photovoltaic power plant in a Verona suburb where there are already experimental plants to obtain electricity and heat from urban waste. This project is being accomplished with the Regional Administration of the city of Verona, and EC support. The Verona photovoltaic plant will cost 10 billion lire (about $8 million), will be built in 2 years on a 2,500-sq.m surface and will use crystalline silicon.

Technology Gap. The Italian National Agency for Hydrocarbons published a study on the trend of export/import in Italian patents and trademarks for 1979-1988. The deficit increased from 300 billion lire in 1979 to 700 billion lire in 1988 with a steady upward trend that was slightly reversed only during the 1985-1987 period.

Molecular Biology Research. The Italian pharmaceutical company, Sigma Tau, and the U.S. company, Merck Sharp and Dohme, have joined forces to build and operate the newly inaugurated Institute of Molecular Biology Research (Institute) located just south of Rome. The supervisor of the Institute is Professor Riccardo Cortese, Professor of Molecular Biology, University of Naples, and Director of the European Department of Molecular Biology, University of Heidelberg. The Institute employs 100 researchers and will carry out research especially in the areas of viral and tumor diseases.

Environment. Ansaldo opened a Research Center for Combustion and Environment (CRIS) in the southern Italian region of Puglia. The CRIS is costing 7.6 billion lire (about $5.8 million) and will conduct research on innovative environmental burners and new combustion processes. The 3-year operation cost is estimated at 20 billion lire.

Italian-U.S.S.R. Cooperation. Olivetti and the Soviet Computer Science Office will provide information systems to Soviet Ministries and will connect electronically Soviet Embassies worldwide. Olivetti will also cooperate with the Soviet Ministry of Merchant Marine to equip ships and ports with computer systems. Aeritalia signed two agreements on wind energy with Soviet Energobalans and Borei, respectively, for wind energy plants of 225 KW/h, and 1,500 KW/h for smaller plants. The agreement provides for the transfer of Aeritalia licenses to Soviet counterparts. Fiat and the Soviet Ministry of Automobile Industry have agreed on a 1,800-billion lire (about $1,440 million) joint venture to produce a small automobile in the Soviet Union by 1993 at the rate of 900,000 cars per year. The cars will be sold in U.S.S.R. and Eastern Europe.

Selenia Presents a New Radar. Selenia is installing a new radar in the Rome and Milan airports that can locate the route of airplanes from 50 to 200 miles away. Selenia developed the new radar in 4 years at a cost of 10-billion lire (about $8 million). The radar is called ALE, an acronym that stands for Architettura Lineare Espandible (Linear Expandable Architecture). The ALE is a bidimensional flat antenna (14 m long and 5 m high with 1,500 dipoles on its surface) can easily distinguish the profile of flying objects and determine their type. Selenia

is going to build six of these radars each year as a result of its research program dedicated to radar imaging. Selenia's research effort is estimated to be 150 billion lire per year (about $120 million). This amount is equal to 17 percent of its business turnover focusing on additional main areas: microelectronics, electro optics, and software engineering.

Large Wind Tunnel to Test HERMES Spacecraft. The Centro Italiano Ricerche Aerospazialia (Italian Center for Aerospace Research) assigned to the Genoa company, Naval Impianti, the contract to design and build a wind tunnel to reproduce the conditions and temperatures of the re-entry to earth of a spaceship. This plant is expected to be the largest of the world's 10 wind tunnels and will be first used to test a new generation of insulating plates that will cover the thermic shield of the European Shuttle HERMES. The SCIROCCO project is expected to obtain in the wind tunnel an incandescent wind at ultrasonic speed with temperatures varying from 2,800 to 9,000°C. Naval Impianti will work in cooperation with two American companies--Aurex Corporation (heat-generating plants), and Fluidain Corporation (hypersonic speed). The basic engineering project must be ready in February 1991 to start building the plant near the town of Capua; it will begin operating early in 1993.

Italy and Japan Cooperate in Space. The umbrella agreement of scientific cooperation signed in 1988 between Italy and Japan, found its implementation in the space area during the recent visit to Tokyo of Senator Learco Saporito, Undersecretary for the University and Scientific Research. The Undersecretary was accompanied by representatives of Italian space industries such as Aeritalia, the Fiat Group, Fiat Spazio, BPD, Telespazio, Fiar, Laben, and Selenia Spazio. They established a joint working group formed by the Italian National Space Agency (ASI) and by the corresponding Japanese Agency, NASDA. Italy spends for space about 1,000 billion lire per year (about $800 million) and Japan about 1,200 billion lire. The areas of cooperation are astronauts training, development of re-entry technologies, microgravity, robotics, geodesy, and minisatellites. On this occasion, Aeritalia and Mitsubishi have formed a joint committee to explore the possibilities of space cooperation between the two companies.

New Research Laboratories Move to Pirelli Tires Former Facilities. The Pirelli Tires former facilities in Milan are being refurbished and are now hosting two advanced research laboratories. The first one operating is the Laboratory of Sensors, which has already obtained encouraging results in gas sensors. The newly established one is the Laboratory for Monocrystals and special materials created to produce crystals of high purity for use in electronics and electro optics. The laboratory will also study new materials for applications in optoelectronics and in high-energy physics.

Both laboratories have been created by the Consorzio Milano Ricerche (Milan Research Consortium), an organization formed with the aim to favor cooperation between university research and industrial innovation.

The consortium announced that in a few months another laboratory of microspectroscopy for biosystems and materials will be created to develop innovative devices for diagnostics in organic tissues. The consortium has also announced that in cooperation with the University of Milan, it will create two university courses on materials sciences and environmental sciences supported by the scientific activities carried out at the laboratories.

ETR 500 Train Connects Rome and Florence. Cooperation among the Italian companies Breda, Ansaldo, Fiat, ABB Trazione, and Design Pininfarina has produced the ETR 500 high-speed train which is composed of two engines and seven cars and can travel 300 km/hour. The train was recently tested between Rome and Florence and covered the 262-km distance in 100 minutes carrying 700 passengers. The Italian railways will begin a regular service with this train next December and have ordered 42 of these trains at a cost of 30 billion lire (about $24 million) each. These trains are similar to the French TGV in their technical features; however, the status of the Italian railways is not sufficient to sustain the development of higher speeds. Extensions of the service between Rome and Milan and Naples will be postponed.

Biotechnology Intellectual Property Discussed in Perugia. The Faculty of Law of the University of Perugia organized a symposium of the Biotechnology Law Forum to discuss patents for biotechnology products. The meeting reviewed the refusal of the Munich Patent Office against the patenting of the "Oncomouse." The rebuttal was based on Article 53 of the European Patent Convention which exempts from industrial protection varieties of plants and animals and the biological methods to obtain them. The discussions at the Perugia meeting tended to hold as patentable only those genetic engineering processes carried out within the living cells because they are repeatable with the basic uniformity. Another topic of the discussion was the definition of "invention" and "discovery," the former being generally patentable while the latter is not. With the development of biotechnology, such a distinction between invention and discovery has become obfuscated by procedures that make the dividing line between the two concepts less distinct. The genetic engineering products, by their connection to life, are considered discoveries. Without the inventiveness of the researcher, they could not exist. Consequently, for their dual character, they may be protected under intellectual property protection regulations.

Italy Neglects Geothermal Energy. According to the Geothermal Research of the National Hydrocarbons Agency (ENI), Italy is the European country richest in geothermal energy. On the other hand, it is fourth in the world for the production of electricity through geothermal energy and seventh place for direct use of geothermal energy. Apparently, the Italian ground is unusually rich in groundwater at temperatures that vary from 70 to $100^{\circ}C$ that could be used for direct heating purposes.

If all the projects that have been studied and considered technically possible would be implemented by 2000, the saving in traditional fuel could equal 2 million tons of oil per year. In 1986, the government made available 35 billion lire (about $28 million) and in 1987, 30 billion lire were added as an incentive to the drilling of hot water wells. Since then, only a small portion of that substantial sum has been used.

The City of Ferrara is heating 12,000 apartments with water at $100^{\circ}C$ obtained from 1,500-m deep wells. A similar project is being arranged for the City of Vicenza by using 70-degree water. In addition, this water, once cooled, could become drinkable. An overall project to heat Milan's airport to offset the threat of fog is considered technically possible. Few agricultural uses have been implemented, but generally, geothermal energy is a resource that lies dormant in the Italian ground.

Ignitor Project is Postponed. The Italian research project on nuclear fusion "ignitor" (inspired by Professor Bruno Coppi, MIT), has obtained from the European Atomic Energy Community (EURATOM) a postponement so that by November 1990, a final research proposal will be presented. The EURATOM had doubts concerning the machine's capability to start the ignition which is the first stage to arrive at nuclear fusion. The marginal uncertainties reported above have made EURATOM decide to request that the Italian technicians of National Agency for Nuclear and Renewable Energies (ENEA) search over the next 4 months for a more reliable methodology. The ENEA will be supported in this endeavour by the technicians of Italian industries like Ansaldo, Fiat, and ABB-Tecnomasio which are directly involved in the project.